

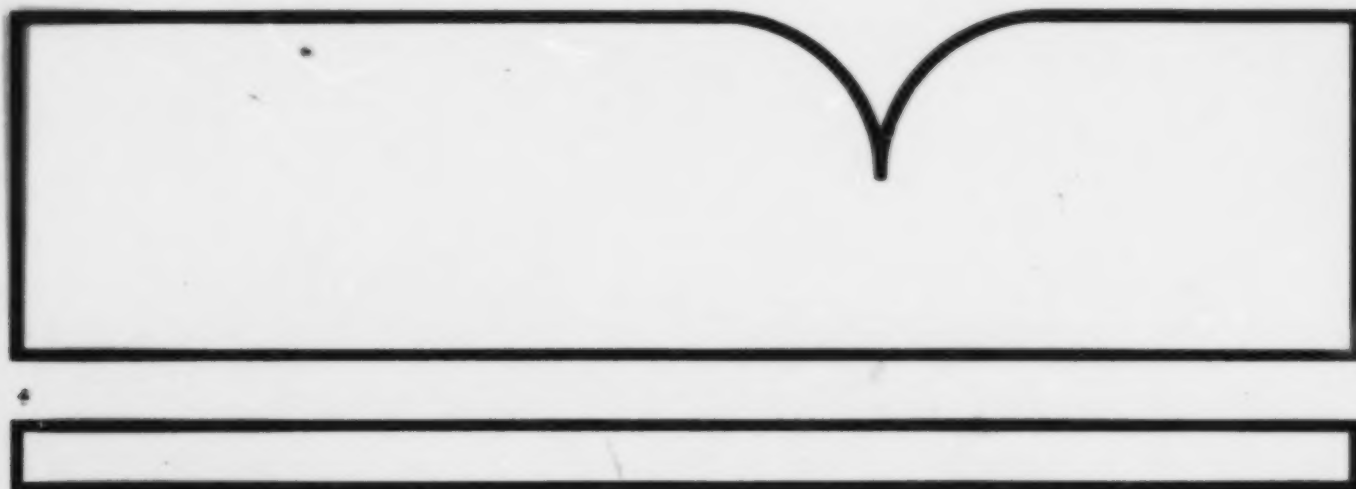
Atmospheric Chemistry of Selected
Sulfur-Containing Compounds Outdoor Smog
Chamber Study - Phase 1

Research Triangle Inst.
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Outdoor Smog
Chamber Study—
Phase 1

Interagency
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Report



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**ATMOSPHERIC CHEMISTRY OF SELECTED
SULFUR-CONTAINING COMPOUNDS
OUTDOOR SMOG CHAMBER STUDY—PHASE 1**

by

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Contract No. 68-02-2437

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ABSTRACT

Selected aspects of the chemical behavior of 14 sulfur-containing compounds were investigated under atmospheric conditions simulated in outdoor smog chambers. In addition to propene, which was used as a control, the following compounds were examined: hydrogen sulfide, carbonyl sulfide, carbon disulfide, methanethiol, methyl sulfide, methyl disulfide, methyl ethyl sulfide, ethanethiol, ethyl sulfide, ethyl disulfide, thiophene, 2-methylthiophene, 3-methylthiophene, and 2,5-dimethylthiophene. Target initial concentrations of 2.0 ppmC of the test compound and 0.1, 0.2, 0.5, and 1.0 ppm NO_x (20 percent NO_2) were employed in the four outdoor smog chambers. Thus, on a single day one test compound was examined at target initial compound/ NO_x ratios of 20, 10, 4, and 2. This approach permits examination of the results of experiments conducted under identical environmental conditions but at different initial NO_x concentrations and hence at different initial compound/ NO_x ratios. A total of twenty 2-day four-chamber runs, or eighty 2-day experiments involving irradiated sulfur species- NO_x or propene- NO_x systems was conducted.

The results of experiments conducted with each compound were analyzed by examination of the influence of initial conditions on selected reaction parameters. These parameters include: the time to NO - NO_2 crossover; maximum concentrations of O_3 , NO_2 , PAN, SO_2 , particulate sulfur, and CN; nitrogen mass balance; time to one-half consumption of the test species; and second-day net ozone concentration. Subsequently, selected reaction parameters were compared across test compounds.

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Several persons in the Environmental Measurements Department of the Research Triangle Institute contributed substantially to this project. Mr. C. E. Decker was Laboratory Supervisor for the project. Mr. D. P. Dayton, Mr. J. C. Mulroy, and Mr. D. L. Ewald conducted day-to-day chamber operations, data reduction, and data verification. Mr. R. O. Lyday developed the computer software for the data handling system and Mr. D. L. Ewald used the system to generate data listings and plots.

We gratefully acknowledge these individuals for their efforts in bringing this project to a successful conclusion.

SECTION 1

INTRODUCTION

During the next several decades, the use of coal, shale oil, and other fossil fuels is expected to increase in the United States to satisfy growing domestic energy needs. Many fossil fuels are dirty, bulky, and difficult to transport, and have low heat content in their raw, natural states. To make these raw fuels more acceptable, fuel conversion processes are being planned and will soon be producing clean, high-energy gas, solid, and liquid synthetic fuels. Operations such as coal gasification and liquefaction, shale oil production, and petroleum refining will assume an increased role in future energy production.

Fuel conversion facilities are potential sources of atmospheric emissions. Contaminants such as mineral matter and sulfur-, nitrogen-, and oxygen-containing compounds are removed and transformed during the processing of raw fuels. Emissions of compounds derived from fuel contaminants are anticipated. In addition, emissions of species from the processing operations themselves are expected to be produced. These atmospheric emissions may include not only the commonly considered pollutants such as SO_x , NO_x , CO, and hydrocarbons, but also other compounds not previously considered from either the toxic or ozone-generative viewpoints. Definition of the identities and emission rates of emitted species as well as an understanding of their atmospheric chemistry will permit the assessment of the impact of synthetic fuels processing on air quality.

OBJECTIVE

The objective of the present study is to conduct smog chamber experiments that are designed to elucidate selected aspects of the atmospheric chemistry of chemical species expected to be present in emissions from fuel conversion facilities. A major goal is to investigate the ozone-producing potential of each test species in combination with various amounts of nitrogen oxides. It is anticipated that the information gained in this study

will aid the EPA Office of Air Quality Planning and Standards in formulating air pollution control strategies.

BACKGROUND

Fuel conversion technology is in the early stages of its development. The identity and emissions rates of species emitted by fuel conversion processes, therefore, are poorly defined. A review of emissions from emerging energy industries was conducted on an earlier RTI contract, EPA 68-02-2258.¹ In this review, a broad spectrum of sulfur-containing compounds, nitrogen-containing compounds, and hydrocarbons was identified from reported analyses of intermediate process streams and final products. The extent to which these species will be released to the atmosphere depends to a large degree on currently undefined processing details. Current estimates are based on engineering process flow diagrams, design material balances, and pilot plant results. Emissions measurements are needed to supplement and verify these estimates.

Coal gasification is a typical fuels conversion process. As with other synthetic fuels processes, only bench- and pilot-scale facilities are currently in operation in the United States. Although several modern commercial facilities are operational outside of the United States, detailed resolution of atmospheric emissions from these facilities is not currently available.

While it is recognized that processes downstream of the gasifier will undoubtedly ameliorate emissions, analyses of the raw effluent from bench- and pilot-scale gasification facilities should provide rough estimates of the compounds that could potentially be emitted. Typical analyses of raw gas from noncommercial gasifiers have been compiled and are presented in Table 1.

Raw gas analyses from the Synthane and Bureau of Mines Fixed Bed processes are presented. In addition, the Research Triangle Institute, through EPA Grant No. 1394 (Pollutants from Synthetic Fuels Production), is conducting a laboratory study to identify emissions from a small batch-fed gasifier. Analyses from two experiments conducted in the RTI gasifier are also presented in Table 1.

Commercial gasification facilities are designed to be continuous operations and to have steady-state operating conditions. Thus, with the excep-

TABLE 1. ANALYSES OF RAW GAS FROM NONCOMMERCIAL GASIFICATION FACILITIES

Process	Synthane	Bureau of Mines	RTI ^{a/}		RTI ^{a/}	
Coal	Illinois No. 6	Western Ky.	Illinois No. 6		Illinois No. 6	
Major Species	(Volume Percent)		b/	c/	d/	e/
N ₂	+	47.6	22.6	26.9	58.8	21.8
CO	12.3	20.6	8.6	16.4	2.8	7.0
CO ₂	35.3	5.9	5.0	17.0	3.3	17.9
H ₂	35.4	13.8	32.6	36.0	8.6	46.8
CH ₄	13.9	2.8	22.7	2.4	15.4	7.6
H ₂ O	++	8.4				
Minor Species (ppm)						
C ₂ H ₆	15,600	NR	8,736	28	25,100	270
C ₂ H ₄	NR	NR	4,836	5	5,000	96
C ₃ H ₈	NR	NR	780	0.0	7,900	120
C ₃ H ₆	NR	NR	1,036	0.0	5,600	52
iC ₄ H ₁₀	NR	NR	50	0.0	600	7
nC ₄ H ₁₀	NR	NR	82	0.0	1,200	< 1
SO ₂	10	NR	0.0	0.0	6	5
H ₂ S	16,200	6,000	18,986	3,979	29,400	5,900
COS	300	1,000	45	30	100	44
CS ₂	NR	NR	39	0.0	27	< 1
CH ₃ SH	30	NR	9	0.0	45	10
C ₂ H ₅ SH	NR	NR	0.0	0.0	69	< 3
Thiophene	40	NR	576	0.0	151	< 5
Methyl Thiophene	10	NR	NR	NR	NR	NR
Dimethyl Thiophene	10	NR	NR	NR	NR	NR
NO	NR	NR	NR	NR	NR	NR
NH ₃	NR	2,500	NR	NR	NR	NR
HCN	< 10 ⁻⁴	NR	NR	NR	NR	NR
Benzene	220	NR	NR	NR	NR	NR
Toluene	50	NR	NR	NR	NR	NR
Xylenes	20	NR	NR	NR	NR	NR

+ Nitrogen-free analysis

++ Water-free analysis

a/ Because of the batch-type operation, data from the RTI gasifier are not necessarily representative of commercial facilities.

b/ Test No. 80131116B2C after 20 minutes; temperature 518°C

c/ Test No. 80131116B2C after 90 minutes; temperature 926°C

d/ Test No. 6A after 18 minutes; temperature 601°C

e/ Test No. 6A after 112 minutes; temperature 778°C

tion of upset conditions, the composition of the effluent from commercial facilities should be relatively constant. In contrast, the RTI gasifier is operated as a batch reactor. It is first heated and then charged with coal. As the coal temperature rises, the composition of the raw evolving product gas changes with time--rapidly at first and then more slowly. In the later stages of a run, once a stable reactor temperature has been attained, the effluent achieves a fairly constant composition. Raw gas analyses from both the early and late stages of two experiments are presented in Table 1. Thus, while the mode of operation of the RTI gasifier prevents these results from being entirely representative of commercial facilities, they should provide suitable estimates of compounds that could be emitted from commercial units.

The raw gas composition, as indicated in Table 1 from RTI gasifier experiments, was determined from gas samples that had been collected in glass bulbs. Raw gas samples were also collected on Tenax and XAD sorbents for subsequent GC/MS analyses. Compounds identified in samples collected on sorbents during Run No. 80131I16B2C are presented in Table 2. Although more comprehensive quantitative analyses of the raw gas are not available at this time, these analyses are sufficient to emphasize the dominant aromatic character of the high molecular weight species that comprise the raw gas. For example, large amounts of toluene, benzene, and naphthalene were identified.

The following compounds were selected for smog chamber investigation in the current study.

H ₂ S	CH ₃ SH	CH ₃ SC ₂ H ₅	(C ₂ H ₅ S) ₂	3-Methylthiophene
COS	CH ₃ SCH ₃	C ₂ H ₅ SH	Thiophene	2,5-Dimethylthiophene
CS ₂	(CH ₃ S) ₂	C ₂ H ₅ SC ₂ H ₅	2-Methylthiophene	

The RTI gasifier experiments that are summarized in Tables 1 and 2 had not been conducted when these compounds were selected. Based on the more recent information provided in Table 1, these still appear to have been reasonable choices.

TABLE 2. COMPOUNDS IDENTIFIED FROM TENAX CARTRIDGE #4
FROM COAL RUN 80131 IL 6B2C (AFTER 75 MINUTES).

Chromatographic Peak No.	Compound	$\mu\text{g/l}$	Chromatographic Peak No.	Compound	$\mu\text{g/l}$
1	CO_2		21b	C_7 -benzene isomer	
1a	carbonyl sulphide		21c	C_7 -thiophene isomer	
2	sulfur dioxide		22	C_7 -benzene isomer	
2a	butene isomer		22a	C_7 -thiophene isomer	
2b	(Freon 11) (BKG)		23	benzofuran + C_7 -benzene	
4	acetone		23a	sulfur compound or unknown	
4a	furan (tent)		24	n-decane	
4b	$\text{C}_8\text{H}_8\text{O}$ isomer (tent)		24a	C_7 -benzene + C_7H_7 -benzene	
4c	$\text{C}_8\text{H}_8\text{O}$ isomer		24b	isomers	
5	dichloromethane (BKG)		24c	saturated hydrocarbon	
5a	carbon disulfide		25	indane	
5b	C_8H_8 (tent)		25a	cresol isomer	
5c	C_8H_8 isomer		26	indene	
5d	C_8H_8 isomer		27	acetophenone	
6	methyl ethyl ketone		28	cresol isomer	
7	hexafluorobenzene T		28a	C_8 -benzene isomer	
7a	C_8H_{14} isomer		28b	C_8 -benzene isomer	
8	perfluorotoluene T		28c	C_8H_7 -benzene isomer	
9	benzene	60	28d	methylbenzofuran isomer	
9a	thiophene	2.2	29	methylbenzofuran isomer	
10	acetic acid	9	29a	C_8 -benzene isomer	
11	n-heptane		29b	C_8 -phenol isomer	
12	toluene	872	29c	C_8H_7 -benzene	
12a	methylthiophene isomer	4	30	methylindene isomer	
12b	C_8H_{10} isomer		31	methylindene + silane compound	
13	n-octane		31a	saturated hydrocarbon	
14	silane compound		32	naphthalene	
15	ethylbenzene	1	32a	benzothiophene	
15a	ethylthiophene	3	33	β -methyl naphthalene	
16	xylene isomer	3	33a	methyl benzothiophene	
16a	dimethylthiophene	2.6	34	α -methyl naphthalene	
16c	dimethylthiophene isomer	0.7	34a	$\text{C}_{12}\text{H}_{10}$ isomer (tent)	
17	C_8H_8 isomer		35	$\text{C}_{14}\text{H}_{20}$ isomer	
18	xylene isomer	1.2	35a	$\text{C}_{12}\text{H}_{10}$ isomer	
18a	dimethylthiophene isomer	0.7			
19	n-nonane				
19a	C_7 -benzene isomer				
19b	hydrocarbon				
20	benzaldehyde	1.3			
20a	C_7 -benzene isomer (tent)				
20b	C_7 -thiophene isomer				
20c	C_7 -benzene isomer				
21	C_7 -benzene isomer	14			
21a	phenol				

SECTION 2

CONCLUSIONS

The purpose of the present study is to investigate selected aspects of the chemical behavior of 14 sulfur-containing compounds under atmospheric conditions simulated in outdoor smog chambers. A major goal is to examine the ozone production of each test compound under various initial conditions.

In addition to propene, which was employed as a control, the following compounds were examined: hydrogen sulfide, carbonyl sulfide, carbon disulfide, methanethiol, methyl sulfide, methyl disulfide, methyl ethyl sulfide, ethanethiol, ethyl sulfide, ethyl disulfide, thiophene, 2-methylthiophene, 3-methylthiophene, and 2,5-dimethylthiophene. Target initial concentrations of 2.0 ppmC* of the test compound and 0.1, 0.2, 0.5, and 1.0 ppm NO_x (20 percent NO₂) were employed in the four RTI smog chambers. Thus, on a single day one test compound was examined at target initial compound/NO_x ratios† of 20, 10, 4, and 2. Twenty 2-day, four-chamber runs, or eighty 2-day experiments involving irradiated sulfur species-NO_x or propene-NO_x systems were conducted. In addition, 8 two-day, four-chamber runs were conducted to characterize the smog chambers. Approximately 220 chamber days of data were collected during the current contract.

In most cases, the photochemical behavior of irradiated mixtures of NO_x and individual test species was similar in various respects to that of irradiated mixtures of NO_x and hydrocarbons such as propene. Except for experiments conducted with H₂S and COS, the presence of the test species

*Since H₂S does not contain carbon, a target initial concentration of 2 ppmV of this compound was used.

†For typical photochemical smog systems the HC/NO_x ratio is a parameter that is normally considered to be an indicator of the system's reactivity. Although it is recognized that the tested sulfur-containing compounds strictly are not hydrocarbons, the term, "HC/NO_x ratio," is nevertheless used in this report instead of "compound/NO_x ratio." Furthermore, this ratio has the units ppmC/ppm for each tested compound, except H₂S where the units are ppmV/ppm.

resulted in more rapid conversion of NO to NO₂ than would have occurred in its absence. For the thiols, organic sulfides, and organic disulfides, conversion from NO to NO₂ was extremely rapid and rather insensitive to initial conditions. The organic disulfides displayed the most rapid conversion of NO to NO₂ of all the species tested in the current study. For carbon disulfide and thiophene, the times to crossover were highly sensitive to initial conditions and, in one case for thiophene, crossover occurred on the second day. A seasonal influence on the times to crossover was exhibited in the propene-NO_x experiments.

One measure of reactivity of an organic is its ozone-forming potential when irradiated in the presence of nitrogen oxides. Since EPA is concerned with the control of organic emissions to control ambient ozone concentration, it is appropriate to compare ozone-production potential of the tested compounds. For each tested compound, the largest maximum concentration of ozone observed in the current study is illustrated in Figure 1. The compounds are listed in the order of descending reactivity as measured by maximum ozone production.

Except for the experiments conducted with H₂S and COS, substantial amounts of ozone accumulated during at least one of the experiments conducted with each test compound. The maximum ozone concentrations were rather sensitive to initial conditions, and the largest [O₃]_{max} generated by tested sulfur species was generated by the CH₃SCH₃-NO_x system. Among the test species the thiols, organic sulfides, and organic disulfides had the largest ozone-production potential, and produced their largest maximum ozone concentrations at low initial HC/NO_x ratios. The largest [O₃]_{max} for the thiols occurred at the target HC/NO_x ratio of 4. Same-day experiments suggest that methanethiol has a larger first-day ozone-generative potential than ethanethiol. For organic sulfides and disulfides the [O₃]_{max} decreased sharply as the target HC/NO_x ratio was increased from 2 to 20.

In general, the thiophenes produced less ozone than the previously mentioned thiols, organic sulfides, and organic disulfides.

Thiophene and 2-methylthiophene produced the largest [O₃]_{max} at the target HC/NO_x ratio of 10, while 3-methylthiophene and 2,5-dimethylthiophene produced the largest [O₃]_{max} values at the target HC/NO_x ratio of 4. Among the thiophenes, 3-methylthiophene produced the most ozone. The addition of

a methyl group onto the heterocyclic thiophene molecule modifies its reactivity as indicated by maximum ozone production. In addition, these results suggest that reactivity is significantly enhanced by the addition of a methyl group at the 3-position in comparison to adding either one or two methyl groups at the 2-position.

The photochemical behavior of irradiated mixtures of NO_x and H_2S was markedly different from that of irradiated mixtures of NO_x and a hydrocarbon such as propene. Hydrogen sulfide did not act to promote the oxidation of NO to NO_2 . Instead, the reverse occurred; NO_2 was reduced rapidly to NO , and essentially no ozone accumulated. The results indicate that the apparent reduction of NO_2 to NO in the presence of H_2S involves a photochemical process.

On the first day of the experiments conducted with carbonyl sulfide, very little NO was oxidized to NO_2 , and essentially no ozone was produced. In most respects the results from irradiating COS and NO_x were no different than those expected from irradiating NO_x in pure air.

Substantial quantities of ozone accumulated in the experiments conducted with carbon disulfide, but only at the highest HC/NO_x ratio. Carbonyl sulfide was found to be a major product in each of the experiments conducted with CS_2 . In addition, COS was observed as a minor product in experiments conducted with nine of the remaining tested sulfur-containing compounds.

Strong seasonal influences on the maximum ozone concentrations were exhibited in the propene- NO_x experiments. Much larger ozone maxima were produced in September, and they were more sensitive to initial conditions than was found in replicate experiments conducted in November. The effect was most pronounced at the target HC/NO_x ratio of 2.

Many of the tested sulfur-containing compounds were found to interfere with the chemiluminescent determination of nitrogen oxides. This is believed to result from the chemiluminescence of species formed within the NO_x analyzer by reaction of ozone with the sulfur-containing test compound.

On the average, at the maximum NO_2 concentration, NO_2 accounted for 47 percent of the initial NO_x in the experiments conducted with the thiophenes. In the experiments conducted with the thiols, organic sulfides, and organic disulfides, this value was 60 percent. The corresponding value in the propene- NO_x experiments was 73 percent.

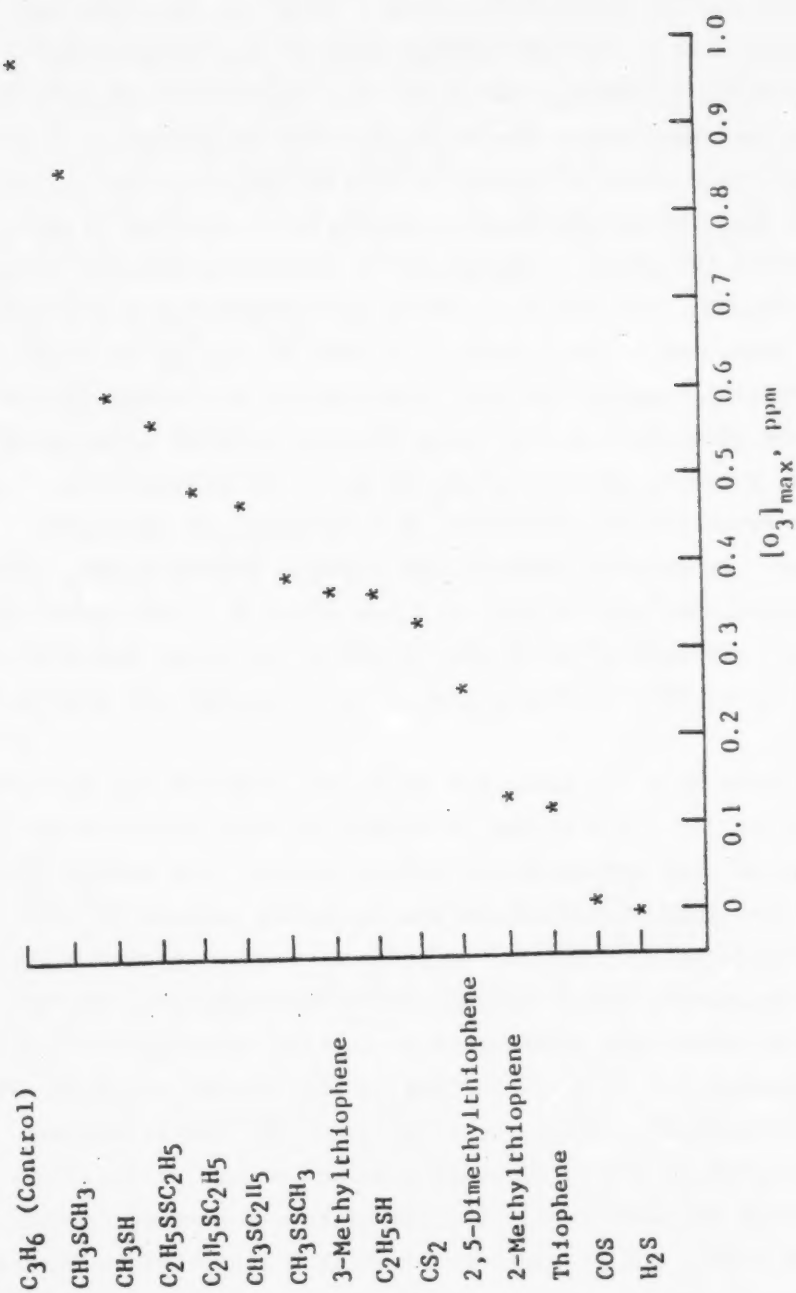


Figure 1. Largest $[O_3]_{max}$ observed for each tested compound.

Methyl nitrate (MN) was tentatively identified as a reaction product in experiments conducted with propene, the tested thiols, organic sulfides, organic disulfides, and 2,5-dimethylthiophene. Ethyl nitrate (EN) was tentatively identified as a reaction product only in experiments that involved C_3H_6 , $CH_3SC_2H_5$, C_2H_5SH , $C_2H_5SC_2H_5$, and $(C_2H_5S)_2$. Appreciable amounts of EN were not found in the experiments conducted with the thiophenes. In every case where EN was found, peroxyacetyl nitrate (PAN) was also found. In addition, PAN was detected in appreciable amounts as a reaction product for the three substituted thiophenes. Based on the chemical structure of H_2S , COS , CS_2 , CH_3SH , CH_3SCH_3 , and $(CH_3S)_2$, PAN is not expected as a reaction product of these compounds. The formation of PAN, MN, and EN as reaction products of the thiols, organic sulfides, and organic disulfides can be rationalized if the photooxidation of these species involves cleavage of S-C bond, which in the presence of air and NO_x leads to their formation.

Evidence was found for the existence of a hypothetical nitrogen-containing species. In several cases at the highest initial HC/NO_x ratios the NO_x concentration exhibited a loss of a few ppb with a subsequent recovery. This behavior occurred after $NO-NO_2$ crossover and coincided with the initial accumulation of PAN. The identity of this hypothetical species is unknown.

Nitrogen balances were estimated for each test compound for the 1700 EST hour of the first day. The poorest nitrogen balances occurred for the experiments conducted with methanethiol, methyl sulfide, and methyl disulfide. Generally less than 15 percent of the initially present NO_x could be accounted for in these cases. For the experiments conducted with methyl ethyl sulfide, ethanethiol, ethyl sulfide, and ethyl disulfide, the nitrogen balances again were relatively insensitive to initial conditions and were similar, with approximately 20 to 45 percent of the initially present NO_x accountable at the 1700 EST hour of the first day. For the thiophenes, the nitrogen balances differed widely, depending on the molecular structure. The range of nitrogen balances for carbon disulfide was similar to those for propene. In these cases, the nitrogen balances were sensitive to initial conditions and ranged from 25 to 75 percent. Nitrogen balances approached unity in the experiments conducted with COS and with H_2S . The unaccountable product nitrogen may have been nitric acid or some other undetermined nitrogen-containing species.

The available data did not permit precise estimates of disappearance rates for H_2S , COS , and CS_2 ; however, they do suggest that more than one day of irradiation was required to achieve one-half consumption of each of these compounds. In addition, it is likely that COS was the least reactive and most stable test species under the experimental conditions employed in the current study. The thiols and organic sulfides had similar ranges of disappearance rates. Among all the tested compounds, the organic disulfides displayed the fastest disappearance rates. Among the thiophenes, 3-methylthiophene displayed the fastest disappearance rate.

Sulfur dioxide was found as a reaction product in at least one of the experiments conducted with mixtures of NO_x and each tested sulfur-containing compound except COS , where SO_2 data were not available.

The largest maximum SO_2 concentrations were produced by the $\text{CH}_3\text{SH-NO}_x$ system. Methanethiol, methyl disulfide, ethyl disulfide, 3-methylthiophene, and 2,5-dimethylthiophene exhibited large SO_2 production potentials. Methyl sulfide, methyl ethyl sulfide, and ethyl sulfide produced low but similar maximum concentrations of SO_2 . Among the thiophenes, 2,5-dimethylthiophene and 3-methylthiophene produced significantly more SO_2 than thiophene or 2-methylthiophene.

Condensation nuclei were produced in the experiments conducted with each of the tested compounds. Propene and COS exhibited the smallest CN production potential with maximum concentrations ranging between 10^2 and 10^3 cm^{-3} . The largest maximum CN concentrations occurred in experiments conducted with H_2S and with CS_2 , where concentrations exceeded 10^5 cm^{-3} . The remaining tested sulfur containing compounds exhibited moderate CN production potential with maximum concentrations generally ranging between 10^4 and 10^5 cm^{-3} .

Particulate sulfur was found as a reaction product in at least one of the experiments conducted with mixtures of NO_x and each of the tested sulfur-containing compounds. The largest particulate sulfur (TPS) concentrations were produced by the $\text{CH}_3\text{SH-NO}_x$ system. Both methanethiol and methyl disulfide exhibited relatively large particulate sulfur production potentials. Methyl sulfide, methyl ethyl sulfide, ethanethiol, ethyl sulfide, ethyl disulfide, and 3-methylthiophene exhibited moderate particulate sulfur production potentials. The three remaining thiophenes generated small maximum particulate sulfur concentrations. Only trace amounts of particulate sulfur were produced by hydrogen sulfide, carbonyl sulfide, and carbon disulfide.

The times of occurrence of maximum sulfur dioxide and particulate sulfur concentrations were examined. Maximum TPS concentrations preceded maximum SO_2 concentrations in many cases. In the experiments conducted with H_2S , COS , and CS_2 , either missing or low concentration data prevented meaningful comparisons. In at least one of the experiments conducted with each of the remaining test species, however, maximum TPS concentrations either preceded or were coincident with maximum SO_2 concentrations.

The ratio of product sulfur as particulate to the total accountable reacted sulfur ([TPS] plus $[\text{SO}_2]$) was determined for many of the tested compounds. Generally, these data indicate that the majority of the accountable product sulfur for the tested species existed as SO_2 and that less than 20 percent of accountable product sulfur existed in the particulate phase. Ratios in excess of 0.2 occurred for methanethiol, methyl sulfide, methyl disulfide, and methyl ethyl sulfide.

Dark-phase ozone half-lives were examined for many of the tested compounds. These results suggest the possible presence of undefined ozone-reactive reaction products in the experiments conducted with carbon disulfide, the thiols, the organic sulfides, the organic disulfides, and the thiophenes.

The largest second-day net ozone concentration was produced in an experiment conducted with methanethiol. Net ozone concentrations exceeding 0.2 ppm accumulated in at least one experiment conducted with propene, with carbon disulfide, with methanethiol, with ethanethiol, and with 2,5-dimethylthiophene. Based on the relatively large ranges of net ozone concentrations for these species, second-day ozone production by these compounds was highly sensitive to the (first-day) initial conditions. In contrast, essentially no ozone accumulated on the second day of experiments conducted with H_2S and with COS .

SECTION 3

RECOMMENDATIONS

Based on currently available information, H_2S , COS , CS_2 , CH_3SH , $\text{C}_2\text{H}_5\text{SH}$, thiophenes, and aromatic hydrocarbons may be released within an organic matrix from fuel conversion facilities. The emissions of sulfur species and the composition of the organic matrix accompanying the sulfur species remain to be defined. The raw gas analyses in Table 1 indicate that ethane, ethene, and C_6 to C_8 aromatics may comprise a considerable portion of the organic matrix. Unfortunately, the relative amounts of these constituents are currently unknown. Source tests are required to verify the presence of these species and more importantly to define the concentrations and relative amounts of various species within the effluent from "typical" facilities.

With the ever-increasing demand for energy, it is likely that future fuel conversion facilities will be located in areas not totally remote from urban centers. Emissions are therefore expected to become mixed with urban plumes after one or more days of transport. Thus, it is anticipated that emissions unique to fuel conversion facilities will encounter photochemically reactive HC-NO_x systems either within the effluents from the fuel conversion facilities themselves, or through mixing with urban plumes, or both.

Regardless of the source, it is likely that the composition of the organic matrix will control the reactivity of the gaseous effluent. It is therefore reasonable to explore the impact of the presence of hydrocarbons on the atmospheric chemistry of various sulfur species. The addition of hydrocarbons to an irradiated mixture of nitrogen oxides and a selected sulfur species may enhance SO_2 production, increase aerosol generation, and accelerate particulate sulfur formation. The ozone-generative potential of organosulfur- NO_x systems could also be modified by the addition of hydrocarbons. These interactions should be explored.

SECTION 4

EXPERIMENTAL

OVERVIEW

This subsection describes the experimental design and provides a general overview of the experiments that were conducted in this study. Detailed descriptions of the smog chamber facility, reagents, measurement methods, data reduction and handling, and experimental procedures are provided in subsequent subsections.

The following compounds were selected for smog chamber investigation in the current study.

H ₂ S	CH ₃ SH	CH ₃ SC ₂ H ₅	(C ₂ H ₅ S) ₂	3-Methylthiophene
COS	CH ₃ SCH ₃	C ₂ H ₅ SH	Thiophene	2,5-Dimethylthiophene
CS ₂	(CH ₃ S) ₂	C ₂ H ₅ SC ₂ H ₅	2-Methylthiophene	

The investigative approach was to use target concentrations of 2.0 ppmC of the test compound in each of the four chambers. The target NO_x concentrations (20% NO₂) were 0.1, 0.2, 0.5, and 1.0 ppm. These experimental conditions correspond to HC/NO_x ratios of 20, 10, 4, and 2. In the present investigation of organosulfur species, dilution experiments were not conducted--the study involved static experiments only.

A total of 20 two-day, four-chamber runs, or 80 two-day experiments involving irradiated organosulfur-NO_x or HC-NO_x systems, were conducted. Eight four-chamber smog chamber characterization experiments were also conducted. Approximately 220 chamber days of data were collected during the current contract. A summary of the experimental program is presented in Table 3. To provide rough indications of the environmental conditions that prevailed during each run day the maximum temperature and the percentage of the total possible minutes of direct sunshine are also tabulated for each day.

TABLE 3. SUMMARY OF THE EXPERIMENTAL PROGRAM^{a/}

Run No.	Date (1977)	% SS ^{b/}		T _{max} ^{c/}		Description
		Day 1	Day 2	Day 1	Day 2	
1	June 29-July 01	91	93	33.9	33.9	Freon-12 Leak Test ^{d/}
3	July 06-07	81	85	37.2	37.8	Ozone Generation with Purified Air ^{d/}
4	July 10-11	78	43	35.0	33.9	Ozone Decay ^{d/}
5	July 15-16	77	76	35.0	35.6	NO Decay ^{d/}
6	July 17-18	79	77	35.0	36.1	NO _x Decay ^{d/}
18	August 08	81	-	33.9	-	Matched Propene-NO _x ^{d/}
23	August 26-27	55	49	28.9	30.0	CH ₃ SH-NO _x , C ₂ H ₅ SH-NO _x ^{e, f/}
24	August 31-Sept. 01	90	96	32.8	32.2	SO ₂ Decay ^{d/}
25	September 02-03	92	80	32.2	33.9	CH ₃ SH-NO _x
27	September 12-13	95	82	25.6	27.8	Propene-NO _x ^{g/}
29	September 18-19	77	74	30.6	30.6	COS-NO _x
30	September 21-22	64	68	26.7	26.1	CS ₂ -NO _x
31	September 23-24	51	36	26.7	27.8	H ₂ S-NO _x
32	September 28-29	64	13	26.1	23.9	CH ₃ SCCH ₃ -NO _x
33	October 03-04	73	76	18.3	19.4	C ₂ H ₅ SH-NO _x
34	October 05-06	99	29	23.9	24.4	(CH ₃ S) ₂ -NO _x
35	October 07-08	34	29	22.2	18.9	(C ₂ H ₅ S) ₂ -NO _x
36	October 10-11	76	55	18.3	19.4	CH ₃ SC ₂ H ₅ -NO _x
37	October 15-16	100	17	20.0	12.8	C ₂ H ₅ SC ₂ H ₅ -NO _x
38	October 17-19	98	92	13.9	20.0	Thiophene-NO _x
39	October 20-21	100	85	18.9	19.4	2,5-Dimethylthiophene-NO _x
40	October 22-23	100	80	23.9	21.7	3-Methylthiophene-NO _x
41	October 30-31	90	49	17.8	16.1	2-Methylthiophene-NO _x
42	November 09-10	71	23	24.4	23.9	CH ₃ SC ₂ H ₅ -NO _x
43	November 11-12	100	83	13.3	8.9	Propene-NO _x
44	November 13-14	100	89	7.8	10.6	Propene-NO _x
46	November 18-19	100	99	15.6	16.1	Thiophenes-NO _x ^{h/}
47	December 03-04	49	0	16.1	13.9	Ozone Generation with Purified Air ^{d/}

^{a/} Unless noted otherwise, data from these experiments are tabulated in the appendix.

^{b/} Duration of solar radiation reported as percent of possible minutes of direct sunshine (see text).

^{c/} Daily maximum temperature in °C.

^{d/} Chamber characterization experiment; data are summarized and discussed in text but are not tabulated in the Appendix.

^{e/} Experiment employed ambient air with no prior purification in Chamber Nos. 3 and 4.

^{f/} Instead of the 2 ppmC target initial concentration of the test species that was used in the other experiments, 5 ppmC was used in this case; replicate CH₃SH-NO_x experiments were conducted in Chamber Nos. 1 and 3 and replicate C₂H₅SH-NO_x experiments were conducted in Chamber Nos. 2 and 4.

^{g/} Experiment employed ambient air with no prior purification in all four chambers.

^{h/} A different thiophene was used in each of the four chambers.

Sixty-eight of the 80 experiments involved the irradiation of sulfur-containing species in the presence of NO_x . The remaining 12 experiments were conducted using the propene- NO_x system as a control (or typical hydrocarbon- NO_x) system. In addition, 32 chamber characterization experiments were conducted. These were a Freon®-12 leak test, NO oxidation, NO_x decay, SO_2 decay, O_3 decay, O_3 generation with purified air, and matched propene- NO_x experiment. Except for the chamber characterization experiments, which are described in the text, the data collected during the experimental program are tabulated in the appendix.

RTI SMOG CHAMBER FACILITY

The Research Triangle Institute Smog Chamber Facility consists of four cylindrically shaped smog chambers. Each chamber has a surface area of 51 m^2 , a volume of 27 m^3 , and a surface-to-volume ratio of 1.9 m^{-1} . Figure 2 illustrates the general design. The chambers are located outdoors, and irradiation is provided by natural sunlight. The walls are fabricated from 0.13-mm (5 mil) thick fluorinated ethene propene (FEP) Type A Teflon® film. The Teflon walls are supported by an interior aluminum framework. The floors are 0.13-mm thick FEP Teflon film laid over a reflective layer of aluminum foil, which serves to raise the light intensity within the chambers and thus compensate for transmission losses through the walls. Mixing in each chamber is provided by a 0.45-m diameter aluminum fan blade on a shaft that is driven at 345 RPM by a 185-W (1/4 hp) motor using a belt-pulley system.

In addition to the chambers proper, provisions have been made for air purification, reactant injection, and sample collection with subsequent instrumental and manual analyses. The overall system is illustrated in Figure 3.

Air Purification Unit

Details of the air purification unit are shown in Figure 4. This unit has three modes of operation: purge, cleanup, and dilution.

During the purge mode, air is supplied by a blower from a 10-m tower. By opening a manway in the floor and allowing the tower blower to force air through each chamber, purge flow rates of up to $2.3 \text{ m}^3 \text{ min}^{-1}$ are attained.

After purging with ambient air, the chambers are sealed and air is

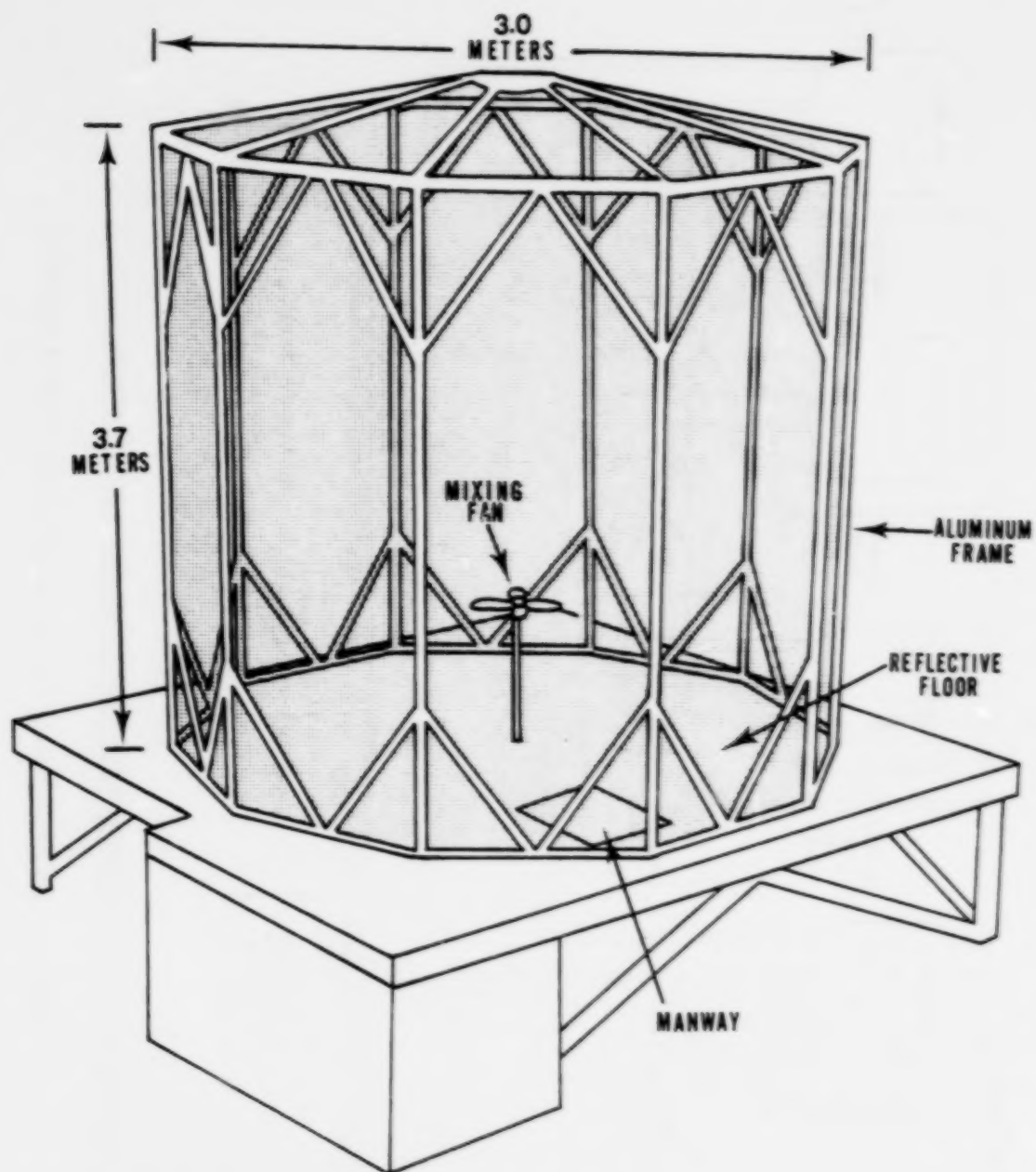


Figure 2. General design of RTI outdoor smog chambers.

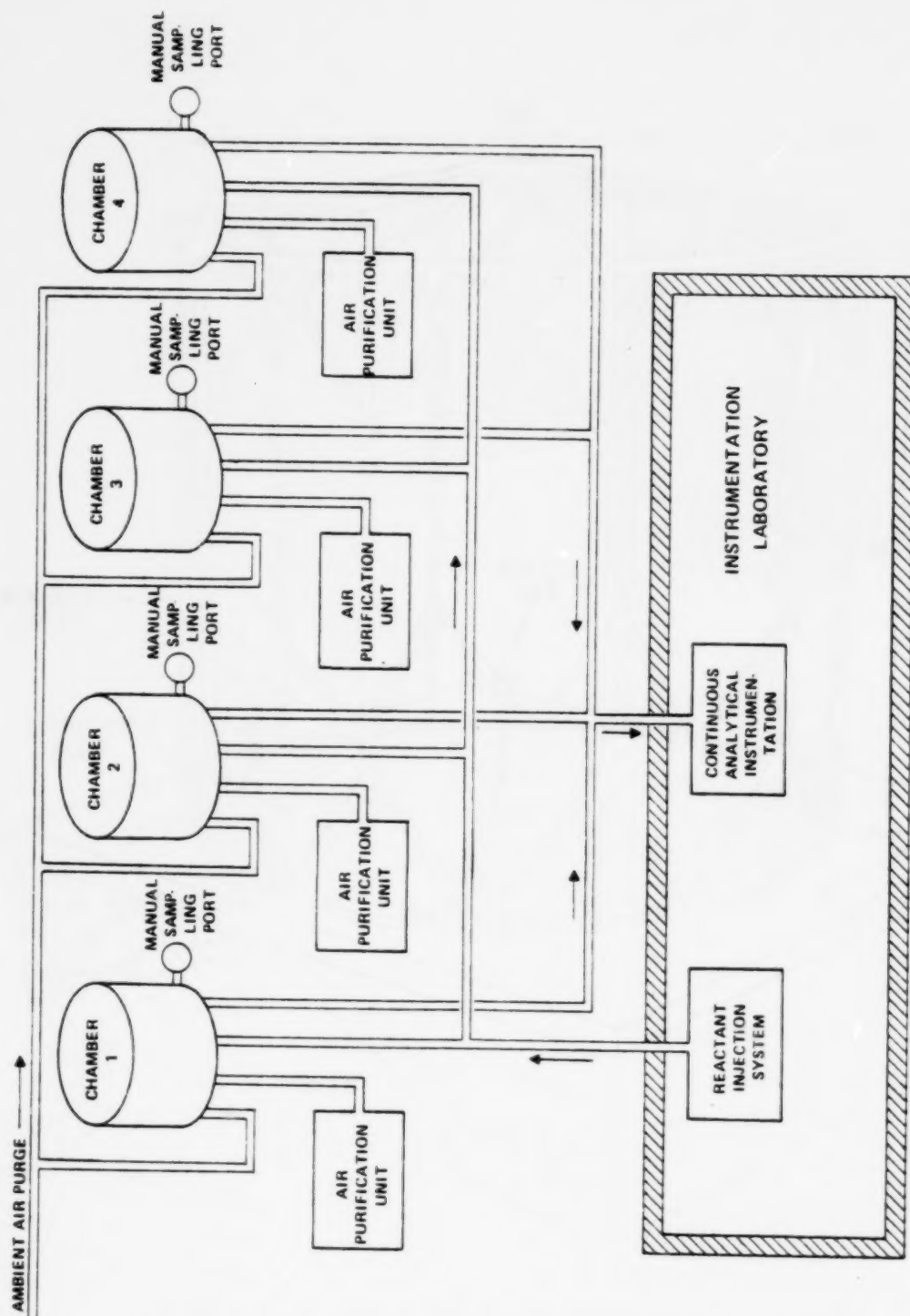


Figure 1. Overall system design of RTI Smog Chamber Facility.

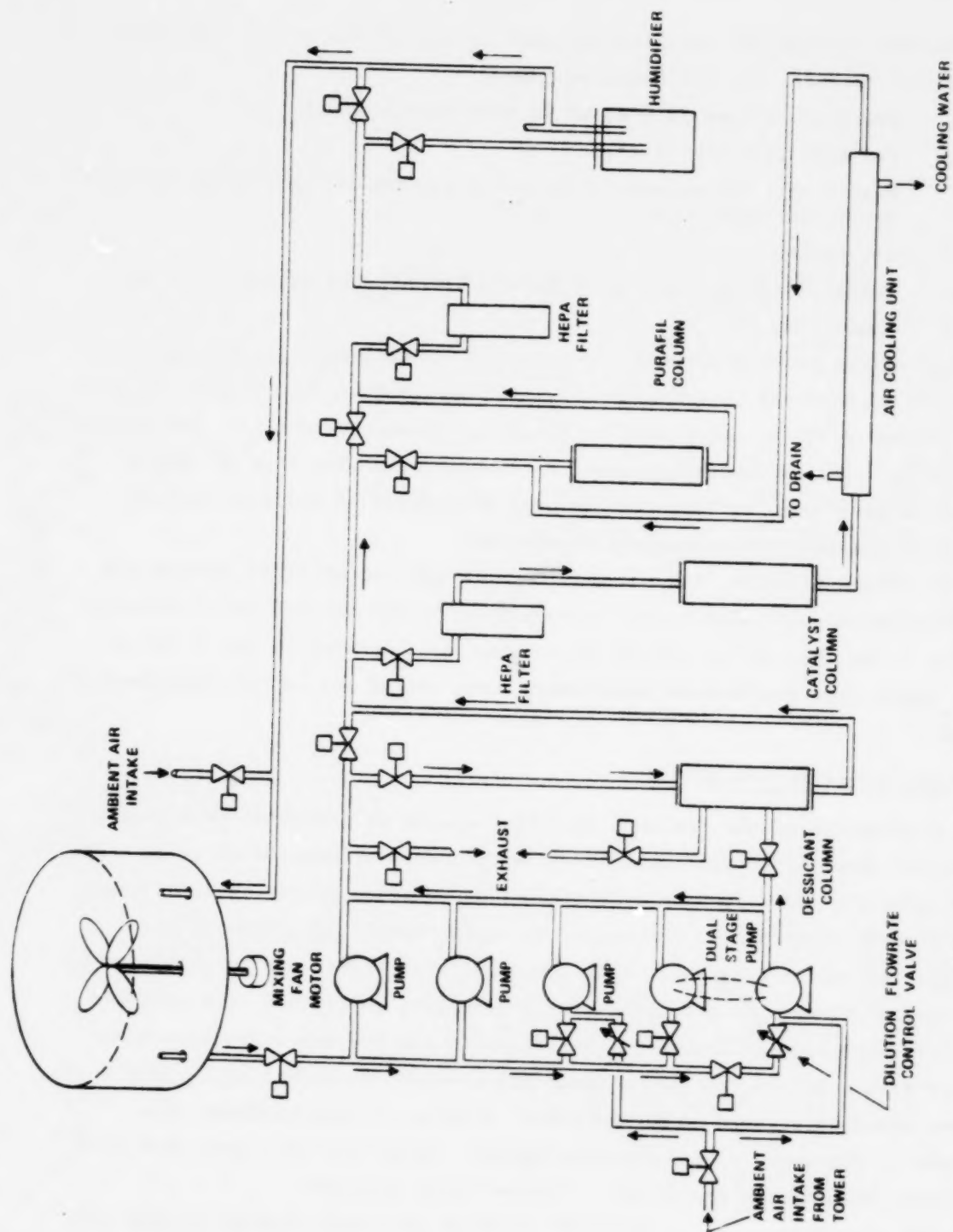


Figure 4. Air purification unit for RTI Smog Chamber Facility.

recirculated through the purification unit in the cleanup mode. The purification unit contains the following equipment:

1. Desiccant column (6.5 kg of 4A molecular sieves);
2. Two HEPA particle filters;
3. Heated catalyst column (5 kg of 0.5 percent Pd on alumina catalyst; operating temperature: 200°-475° C);
4. Air cooler;
5. Purafil[®] column (6.5 kg of Purafil for NO_x and O₃ removal); and
6. Humidifier.

Solenoid-driven valving permits the inclusion or exclusion of this equipment as may be appropriate in achieving desired experimental conditions. In this study, items 2, 3, 4, and 5 were included for cleanup operation. The purification or "cleanup" operation requires 8 hours at a flow rate of approximately 0.28 m³ min⁻¹. Pollutant removal efficiency of the purification unit is discussed in a subsequent subsection.

To effect dilution, the chamber contents are recirculated through the purification unit at flow rates corresponding to the desired dilution rate. In this study, the air purification unit was not operated in the dilution mode, since only static-mode experiments were called for in the experimental design.

Reactant Injection System

A schematic of the reactant injection system is presented in Figure 5. There are three injection manifolds from cylinders of compressed gases. The flow rates are controlled by calibrated fine metering valves, and the quantity of each injection is controlled by timed, manual operation of the appropriate solenoid valves. Although a hydrocarbon mix was not employed in the current study, the provisions for hydrocarbon injections from a copper manifold are shown in Figure 5. Nitric oxide and NO₂ are injected sequentially from a Teflon manifold. Ozone may be added by injecting O₂ from a copper manifold through an O₃ generator, located at each chamber; this feature is employed in O₃ decay experiments. After the reactants have been injected, each of the manifolds is flushed with nitrogen.

The test compounds are directly injected into each chamber through the manual sampling port. Pure gases such as Freon-12, SO₂, H₂S, CH₃SH, COS,

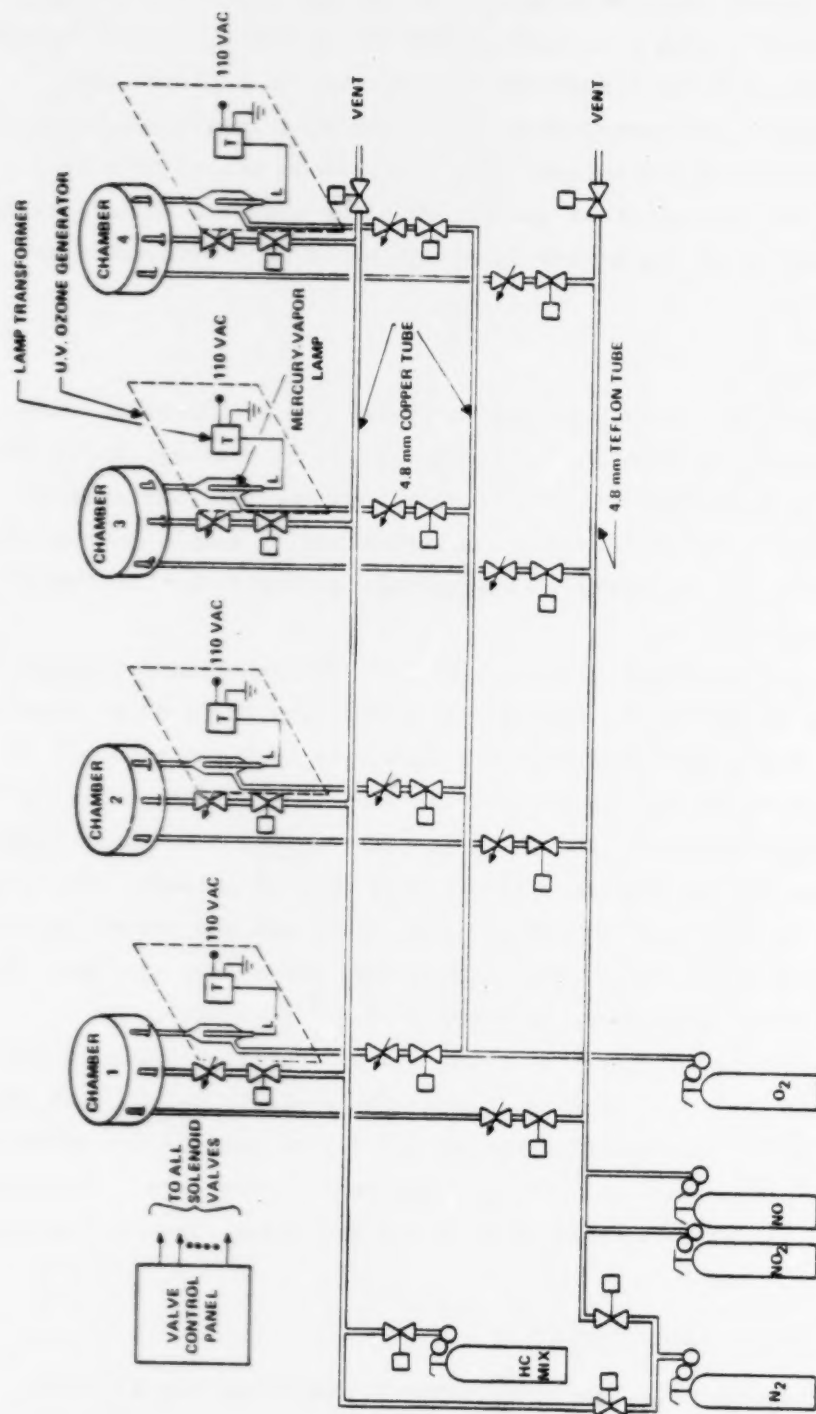


Figure 5. Reactant injection system for RTI Smog Chamber Facility.

and C_3H_6 are introduced into the chambers via syringe injection through a nitrogen-purged 0.5-m length of 4.8-mm ID FEP Teflon tubing. Pure liquids such as C_2H_5SH , CS_2 , and the thiophenes are injected as liquids from a syringe into a heated, nitrogen-purged, glass and stainless steel injection manifold where volatilization occurs. The manifold is heated to a few degrees above the boiling point of the organosulfur compound that is being injected. A schematic of the heated injection manifold is presented in Figure 6.

Sampling System

The sampling system is illustrated in Figure 7. An automatic timer activates the appropriate sampling solenoid valves and provides for a 10-minute sample from each chamber once per hour. During the remaining 20 minutes of each hour, the instruments can automatically sample ambient air from the 10-m tower, or the operator is free to calibrate the instruments or analyze bag samples.

The sampled air must pass from a chamber to the laboratory through lengths of 4.8-mm ID TFE Teflon tubing that range from 26 to 48 m, depending on the chamber. The sample is drawn at a flow rate of $0.005 \text{ m}^3 \text{ min}^{-1}$ (5 l/min) by a Metal-Bellows MB-41 pump located in the laboratory. The sample is delivered to a glass manifold from which the instruments draw their samples. The residence time in the sampling line is less than 10 seconds. The instruments include an O_3 analyzer, a $NO-NO_2NO_x$ analyzer, and gas chromatographs designed to determine C_1 to C_5 hydrocarbons, PAN, and sulfur species. The total volumetric flow requirement is $0.003 \text{ m}^3 \text{ min}^{-1}$ (3 l/min).

In addition to the automated sampling system described above, a port is located in the vertical wall of each chamber for periodic manual grab sampling (see Figure 3). Condensation nuclei and filter samples for subsequent determination of particulate sulfur are collected at this point. Typically, grab samples are collected several times a day from each chamber (see the appendix for exact times).

Smog Chamber Operating Characteristics

Operating characteristics of the chambers comprising the RTI Smog Chamber Facility are documented in the following paragraphs. This informa-

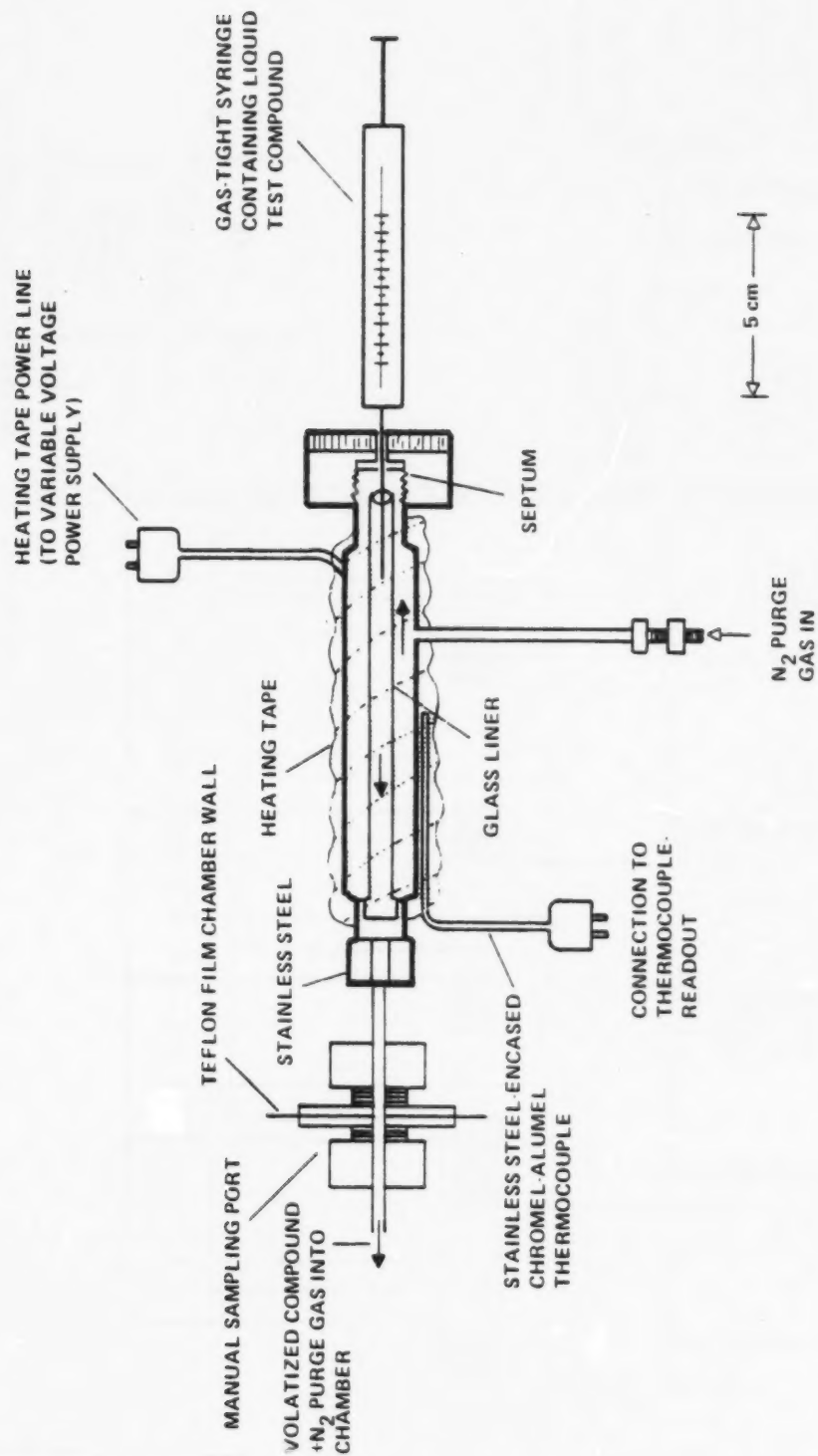


Figure 6. Heated stainless steel manifold for volatilizing liquid test compounds prior to injection into a smog chamber.

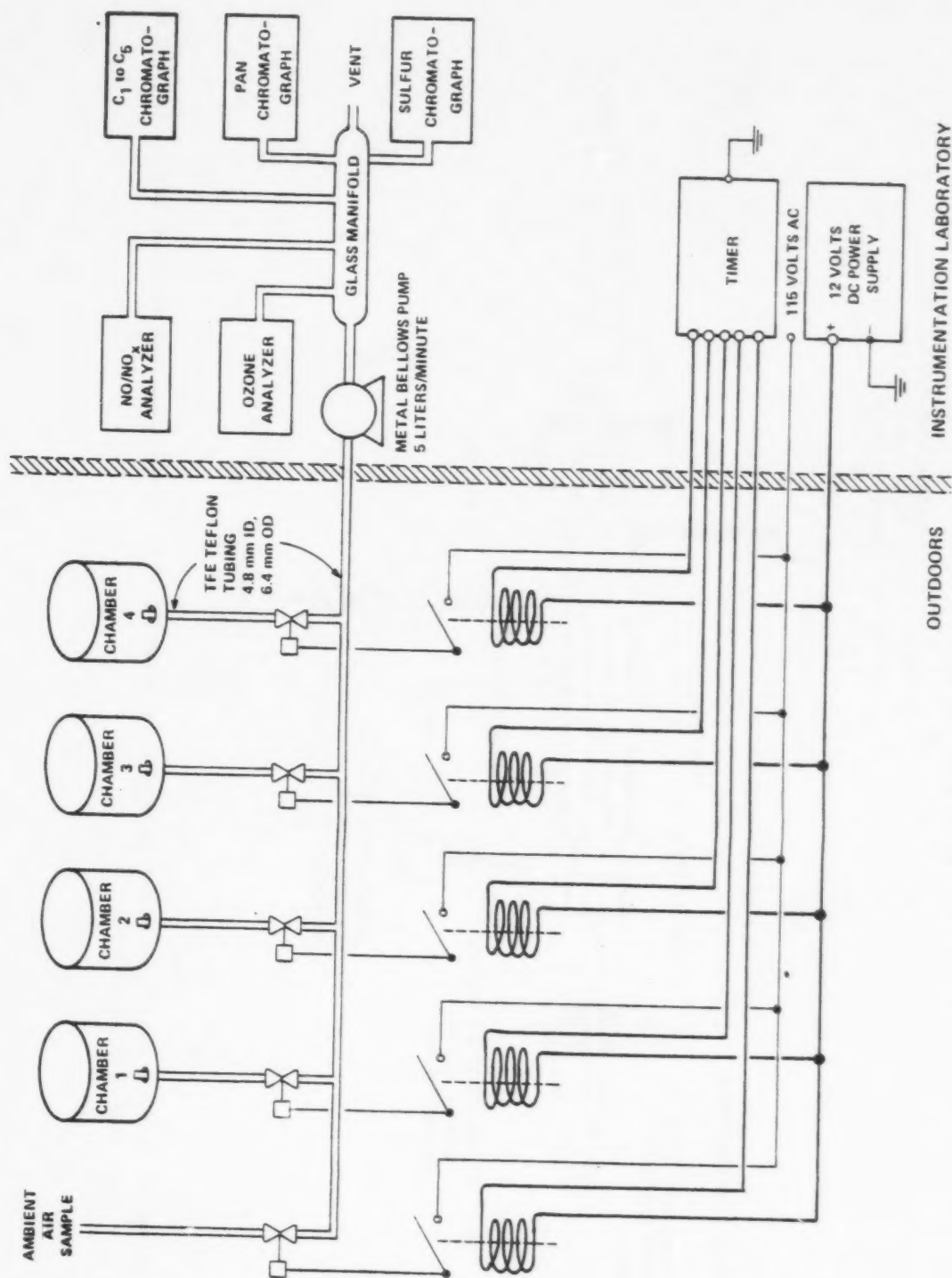


Figure 7. Sampling system for RTI Smog Chamber Facility.

tion is reported to provide a basis for assessing the performance of the RTI chambers and to permit comparison with other chambers.

Mixing--

As noted earlier, mixing in each chamber is provided by a fan designed for that purpose. Unless specified otherwise, the fan operated continually during each experiment.

Air velocity measurements have been conducted within each chamber. The minimum air velocity was measured to be greater than 0.05 m sec^{-1} within 0.02 m of the floor. Air velocities increased with distance from the walls to a maximum that was greater than 4.0 m sec^{-1} near the moving fan blade.

If a smog chamber can be considered to be an agitator-stirred tank, then a published relationship can be used to estimate the time required for complete mixing.² This procedure indicates that the mixing of an injected gas should be 90 percent complete within 24 seconds and 99 percent complete within 43 seconds after injection.

Performance of Air Purification System--

The air purification system routinely reduces the NO_x content of the purified air to a measured zero (minimum detectable concentration (MDC): 0.005 ppm). As reported in a previous study,³ the catalytic hydrocarbon oxidation system typically reduces C_2 to C_{10} hydrocarbons measured by gas chromatography to less than 20 ppbC (MDC: 0.1 ppb [v/v]). Samples collected from three of the chambers during the current study on 10 and 11 November 1977 revealed precleanup C_2 to C_5 hydrocarbon concentrations of 27.5, 14.2, and 18.4 ppbC and postcleanup levels of 0.0, 2.4, and 2.2 ppbC . These results illustrate the effectiveness of the air purification system.

Chamber Tightness--

Exchange of chamber contents with the ambient atmosphere is expected. Chamber leaks may be attributed to replacement of the volume required by sampling and to chamber "breathing" caused by diurnal temperature variations and buffeting by winds. During the first two years of operation of the RTI smog chambers, 1975 and 1976, the average daily leak rate coefficients were observed to increase from 0.005 hr^{-1} to values greater than 0.015 hr^{-1} .³ Just prior to the commencement of the current study in May of 1977 the Teflon walls were replaced, and leak rate coefficients were redetermined.

To quantify chamber leakage, first order leak rate coefficients were estimated by least squares regressions of $\ln$ [tracer] versus time data. Freon-12 was used as the inert tracer. Results of these experiments are summarized in Table 4.

The nighttime leak rate coefficients ranged from 0.002 to 0.005 hr^{-1} with a mean of $0.0035 \pm 0.0010 \text{ hr}^{-1}$. The daytime values ranged from 0.003 to 0.012 hr^{-1} with a mean of $0.0063 \pm 0.0026 \text{ hr}^{-1}$. Overall leak rate coefficients for the four smog chambers determined for the three-day experimental period were in excellent agreement. The mean overall value for the four chambers was $0.004 \pm 0.0007 \text{ hr}^{-1}$, which corresponds to dilution of 10 percent in 24 hours. The leak rate coefficients observed in the RTI chambers compare favorably with the value of 0.01 hr^{-1} reported for the newly constructed UNC outdoor smog chambers.⁴

The sampling flow rate of 0.005 $\text{m}^3 \text{ min}^{-1}$ for 10 minutes per hour corresponds to a loss coefficient of 0.002 hr^{-1} or dilution of 5 percent in 24 hours. If 0.005 hr^{-1} is taken to be typical for the current program, then environmental factors account for over half of the leakage. The results in Table 4 indicate that the daytime leak rate coefficients are approximately twice as large as the nighttime values. This difference may be due to increased wind speeds normally observed during the day and suggests that buffeting by winds may be responsible for leakage in excess of that required for sample replacement.

Unless noted to the contrary, the concentration data reported in the present study were not adjusted to correct for dilution.

Sample Line Losses--

The most distant chamber is 48 m from the instruments in the laboratory. When NO , NO_2 , and O_3 are present in a chamber during periods of irradiation, a small reduction of NO and O_3 and a slight increase in NO_2 may occur in the dark sample line due to the dark-phase reaction of NO and O_3 .⁵ In view of the short residence time (10 seconds), this contribution should be small in most cases, and the data were not corrected for these effects.

The sampled air volume must pass through a considerable length of sampling line (26 to 48 m) and a pump before it is delivered to the instruments for analysis. Sample modification is expected. In a recent investigation

TABLE 4. LEAK RATE COEFFICIENTS IN RTI SMOG CHAMBERS
BASED ON FREON-12 MEASUREMENTS

Date	Leak Rate Coefficient ^{a/}				Comment
	Chamber 1	Chamber 2	Chamber 3	Chamber 4	
6/29, 30/77	0.0051	0.0048	0.0048	0.0043	Nighttime, 2000 to 0400 EST
6/30, 7/1/77	0.0032	0.0033	0.0027	0.0025	Nighttime, 2000 to 0400 EST
7/1, 2/77	0.0032	0.0028	0.0024	0.0026	Nighttime, 2000 to 0400 EST
6/29/77	0.0086 (1.7) ^{b/}	0.0116 (2.4)	0.0071 (1.5)	0.0090 (2.1)	Daytime, 1000 to 1900 EST
6/30/77	0.0042 (1.3)	0.0057 (1.7)	0.0028 (1.0)	0.0040 (1.6)	Daytime, 0500 to 1900 EST
7/1/77	0.0056 (1.8)	0.0076 (2.7)	0.0039 (1.6)	0.0054 (2.1)	Daytime, 0500 to 1900 EST
6/29-7/2/77	0.0044	0.0053	0.0037	0.0041	Overall

^{a/}First order loss coefficient as determined from the slope of least squares regressions of $\ln$ [tracer] versus time data; the tracer is Freon-12; units: hr⁻¹.

^{b/}The ratio of daytime to nighttime leak rate coefficients is enclosed by parentheses.

of sampling line loss rates,³ single-component mixtures of air and O₃, NO, and NO₂ were prepared in Teflon bags at 3 to 5 concentrations ranging between 0.08 and 1.0 ppm. Concentrations were determined initially by sampling each bag directly at the instrument in the laboratory and subsequently by connecting the bag to the sampling line located within each chamber and by sampling in the usual manner. Sampling line losses for O₃, NO, and NO₂, were found to be less than 1 percent and to be independent of concentration.

Similar investigations were conducted in the present study for SO₂ and PAN. Sampling line losses for SO₂ and PAN were found to be less than 8 percent and to be independent of concentration. The O₃, NO, NO₂, SO₂, and PAN data reported in the appendix were therefore NOT corrected for sample line losses.

Characterization Experiments--

The role of surface-mediated reactions in smog chamber investigations is unclear. Contamination or "dirty chamber" effects have been observed in glass, aluminum, and Teflon chambers.^{6 7 8} The levels of background FID-responsive contaminants that are released by Teflon film vary from batch to batch.^{9 10 11} Teflon film is the currently accepted material of choice for the fabrication of smog chamber walls. However, the experimental conditions for which the influence of chamber-associated contaminants may be safely neglected are yet to be defined.

In addition to the Freon-12 leak test discussed previously, five types of chamber characterization experiments were conducted to document the behavior of the RTI smog chambers with respect to contaminant-associated effects: purified air irradiations, O₃ decays, NO oxidations, NO_x decays, and SO₂ decays. In addition to considering data from the chamber characterization experiments identified in Table 3, results from selected characterization experiments conducted under a subsequent study were considered. The results of these experiments are presented in Tables 5, 6, 7, 8, 9, and 10.

The purpose of the purified air irradiations was to document the maximum concentration of ozone, [O₃]_{max}, that accumulated in the RTI smog chambers when purified air was irradiated. Ozone is generated by photochemical processes involving trace levels of nitrogen oxides and organics. These contami-

nants either remain in the air after purification or desorb from the chamber walls. Results from these experiments are summarized in Table 5. Ozone levels generated in the RTI chambers on the first day of purified air irradiations ranged from 0.02 to 0.11 ppm. A seasonal effect is apparent: the largest $[O_3]_{\max}$ occurred in July of 1977; whereas, the smallest $[O_3]_{\max}$ occurred in December of 1977. The results of multiple-day experiments indicate that, on the first day, ozone levels near 0.08 ppm could be achieved. Also, second-day maximum ozone concentrations could exceed the first-day levels. The $[O_3]_{\max}$ values presented in Table 5 compare favorably with the range of values of 0.03 to 0.17 ppm reported for 1975 and 1976 in the RTI smog chambers,³ with the value of 0.14 ppm reported for the outdoor UNC facility,⁴ and with the values of 0.04,⁸ 0.05,¹⁸ 0.10,¹² and 0.22⁸ ppm reported for indoor chambers.

It is unclear how the results from purified air irradiations may be related to results from HC-NO_x experiments. While purified air irradiations may indicate the level of chamber-associated contaminants relative to other purified air irradiations, they may not be accurate indicators of the effects of these contaminants in HC-NO_x experiments. These effects may be overshadowed completely in photochemically reactive HC-NO_x systems. It is expected that as the absolute reactant concentrations and their ratio change, the impact of chamber effects on the overall behavior of the system will also change. Chamber influences are anticipated to be nonlinear with changing reactant concentration, and the experimental conditions at which chamber-related influences begin to dominate the behavior of chemical systems remain to be defined.

It should be noted that the $[O_3]_{\max}$ that accumulates during a single irradiation period is the net result of both ozone-formation and destruction reactions that occur within a smog chamber. It is possible for a given chamber to have a low light-phase ozone-destructive component, low absolute concentrations of background contaminants (ozone precursors) and yet achieve a higher $[O_3]_{\max}$ than another more contaminated chamber with a higher light-phase ozone-destructive component. Thus, in the comparison of $[O_3]_{\max}$ values achieved in clean air irradiation experiments conducted in various chambers, the ozone-destructive component under irradiation should be considered.

TABLE 5. MAXIMUM OZONE CONCENTRATION ACHIEVED IN RTI SMOG CHAMBERS
DURING PURIFIED AIR IRRADIATION EXPERIMENTS

Date	% SS ^a / T _{max} ^b	[O ₃] _{max} , ppm				Comment
		Chamber 1	Chamber 2	Chamber 3	Chamber 4	
7/6/77	81	37.2	0.111	0.072	0.101	Two-day experiment
7/7/77	85	37.8	0.177	0.119	0.193	
12/3/77	49	16.1	0.021	0.027	0.032	Two-day experiment
12/4/77	0	13.9	0.014	0.017	0.021	
4/21/78 ^d	48	13.9	0.015	0.023	0.027	Two-day experiment
4/22/78 ^d	100	19.4	0.052	0.065	0.077	
					0.167 ^c / 0.200 ^c	
					0.028 0.019	
					0.032 ^c / 0.082 ^c	

^a/Duration of solar radiation reported as percent of possible minutes of direct sunshine (see text).

^b/Daily maximum temperature in °C.

^c/A malfunction in the cleanup system reduced the effectiveness of the purification system; the listed results are for a mixture of ambient and purified air.

^d/Characterization experiment conducted in a project subsequent to the present study.

Ozone can disappear inside a chamber by interacting heterogeneously with the walls or by reacting homogeneously with contaminants present inside the chamber. Ozone decay rates reported as half-lives under both dark conditions and irradiation have been used as measures of smog chamber reactivity. For fixed-volume smog chambers, the apparent O_3 half-life is influenced by chamber leakage. Since leak rates were not determined for the O_3 decay experiments, the O_3 half-lives listed in Table 6 were not corrected for leakage. Leak rate coefficients in the RTI chambers as shown previously in Table 4, range from 0.002 to 0.012 hr^{-1} . The half-lives for an inert tracer that correspond to these leak coefficients are approximately 300 and 60 hours. Although in most cases the correction for leakage is small, the apparent wintertime dark phase half-lives listed in Table 6 may be almost entirely due to leakage rather than chemical reaction.

The ozone half-lives listed in Table 6 reflect consistent behavior from chamber to chamber. Dark-phase half-lives range from 24 to 122 hours and display a seasonal influence. It has been shown that in Teflon bags the dark phase ozone half-lives increase with reduced water vapor concentration.⁶ The summer-to-winter increase in the dark-phase ozone half-lives may result from the lower absolute humidity that prevails during the cooler winter months. Although the lower wintertime temperatures may also be a factor, the data do not permit an assessment of the relative importance of humidity and temperature effects.

Ozone half-lives under exposure to natural irradiation range from 9.5 to 39 hours. Based on these results, a reasonable estimate of the ozone half-life in the RTI chambers on a sunny summer day may be 10 to 12 hours. Daytime half-lives are reduced in comparison to the corresponding dark-phase results. During the same season for multi-day experiments, ozone half-lives also generally decrease with increasing % SS. Since the enhanced decay of ozone for irradiated conditions is attributed mainly to secondary reactions following ozone photolysis,⁶ the observed dependence of ozone half-lives on insolation is expected.

In addition to the effects of insolation during the same season, a seasonal influence is observed as well--daytime half-lives increase from summer to winter. Light-phase ozone half-lives have been shown to increase with decreasing water vapor concentration.⁶ Thus, it is likely that the summer-

TABLE 6. OZONE HALF-LIVES IN RTI SMOG CHAMBERS^{a/}

Date	SS ^{b/}	T _{max} ^{c/}	Chamber 1		Chamber 2		Chamber 3		Chamber 4	
			[O ₃] _i ^{d/}	t _{1/2} ^{e/}	[O ₃] _i	t _{1/2}	[O ₃] _i	t _{1/2}	[O ₃] _i	t _{1/2}
7/10, 11/77 ^{f/}	dark	---	0.886	24.3	0.915	29.1	0.891	43.3	0.878	29.2
2/1/78 ^{g,h/}	dark	---	0.841	48.1	0.830	52.1	0.841	60.3	0.812	50.2
2/1, 2/78 ^{h,i/}	dark	---	0.573	68.6	0.608	93.7	0.634	121.9	0.569	66.6
2/2, 3/78 ^{h,i/}	dark	---	0.386	43.6	0.446	51.7	0.482	66.0	0.389	49.2
7/21, 22/78 ^{f,h/}	dark	---	0.442	30.7	0.479	38.3	0.418	30.5	0.415	30.9
7/10/77 ^{j/}	78	35.0	0.910	11.1	0.913	9.5	0.908	13.4	0.888	11.2
7/11/77 ^{k/}	43	33.9	0.703	13.0	0.753	12.8	0.782	17.2	0.724	14.6
2/1/78 ^{h,i/}	92	3.9	0.751	26.3	0.753	33.5	0.773	35.9	0.732	27.4
2/2/78 ^{h,i/}	69	3.9	0.502	27.7	0.552	34.8	0.589	38.5	0.499	28.9
2/3/78 ^{h,u/}	94	2.2	0.317	21.9	0.380	30.4	0.424	34.7	0.326	27.1
7/21/78 ^{h,i/}	100	13.9	0.868	13.0	0.881	14.4	0.863	12.8	0.861	13.1

^{a/}Experiments conducted on 7/10, 11/77 employed ozonized, purified air; those conducted on 2/1, 2, 3/78 employed ozonized ambient air with no prior purification.

^{b/}Duration of solar radiation reported as percent of possible minutes of direct sunshine (see text).

^{c/}Daily maximum temperature in °C.

^{d/}Initial ozone concentration in ppm.

^{e/}Half-life in hours; calculated from the slope of least squares regressions of ln[O₃] versus time data.

^{f/}Experiment conducted from 2100 EST until 0500 EST.

^{g/}Experiment conducted from 0000 EST until 0700 EST.

^{h/}Characterization experiment conducted in a project subsequent to the present study.

^{i/}Experiment conducted from 1900 EST until 0700 EST.

^{j/}Experiment conducted from 0600 EST until 2000 EST.

^{k/}Experiment conducted from 0500 EST until 1200 EST.

^{l/}Experiment conducted from 0800 EST until 1800 EST.

^{m/}Experiment conducted from 0800 EST until 1700 EST.

to-winter increase of light-phase ozone half-lives is due to the reduced duration and intensity of solar radiation in combination with drier air that prevails during the cooler winter season. As with the dark-phase ozone behavior, although ambient temperature may be a factor, the data do not permit assessment of the importance of temperature effects on the light-phase ozone behavior.

Ozone half-lives reported for various smog chambers are summarized in Table 7. Results from the current study are in excellent agreement with 1975 and 1976 findings for the RTI smog chambers.³ Comparison of the ozone half-lives for the RTI chambers with those reported for other chambers indicates that the RTI chamber surfaces are relatively unreactive with O_3 . In addition, the dark-phase O_3 half-lives listed in Table 6 are in accord with a recently reported value of 116 hours⁹ that was estimated for an elevated air parcel that was traveling downwind of the St. Louis area at night.

The oxidation of NO should proceed in the dark by the third-order thermal reaction, $NO + NO + O_2 \rightarrow 2 NO_2$. In the dark, in the absence of reactive organic species, the above thermal reaction should be the major pathway for NO disappearance. For the NO oxidation experiments conducted on 15 and 16 July, apparent second order rate constants for NO disappearance were determined from the slope of least squares regressions of $[NO]^{-1}$ versus time data. For fixed-volume smog chambers, the apparent second order rate constant must be corrected for chamber leakage. Leak rate coefficients based on the simultaneous dark-phase loss of NO_x were estimated for each experiment from the slope of least squares regressions of $\ln [NO_x]$ versus time data (see Table 9). The apparent second order rate constants for NO oxidation were then corrected for chamber leakage as reflected by NO_x loss.¹⁸ Ratios of both the apparent and leak-corrected rate constants to the established value of $1.77 \times 10^{-2} \text{ ppm}^{-1} \text{ hr}^{-1}$ ²⁴ are presented in Table 8. The uncorrected ratios of rate constants range from 1.4 to 2.0 and the corrected ratios range from 1.1 to 1.4. These ratios are in good agreement with values reported previously for the RTI chambers and suggest good agreement between the established value of the dark-phase NO oxidation rate constant and the value as determined in the RTI chambers.

TABLE 7. SUMMARY OF OZONE HALF-LIVES FOR VARIOUS SMOG CHAMBERS

Chamber		Construction Material	Volume, l	Half-lives, hr ^{a/}		Illumi- nation ^{b/}	Reference
Identity				Dark	Light		
Bureau of Mines	Al, Teflon film		1.8 x 10 ³	12	1 (54° C) 3.6 (34° C)	A	15
Bureau of Mines	Al, glass		2.8 x 10 ³	14	6	A	15
Battelle	Al, Teflon film		1.7 x 10 ⁴	8	1.5 (27° C)	A	16
Shell	Stainless steel		4.0 x 10 ²	1.7-6 (24° C)	1.3-2.5 (30° C)	A	17
Exxon	Al, Teflon film		4.3 x 10 ³	13.9	2.7	A	18
SRI	Teflon-coated Al		7.7 x 10 ³	20	7.8	A	19
CSARB	Glass		3.1 x 10 ⁴	---	5.8	A	20
SAPRC	Teflon-coated Al		5.8 x 10 ³	6.8	4.2 (29° C)	A	21
--	Teflon bag		1 x 10 ²	9.5	---	A	22
Lockheed	Glass		1.9 x 10 ³	7.2 (35° C)	3.0 (35° C)	A	23
General Motors	Stainless steel		8.4 x 10 ³	10.0	2.0	A	24
--	Tedlar Bag		4.4 x 10 ²	11.9	---	A	25
UNC	Al, Teflon film		1.6 x 10 ⁵	49-75 ^{c/}	16-23 ^{c/}	N	7
UNC	Al, Teflon film		2.0 x 10 ⁵	21.2	9.4 ^{d/}	N	26
--	Teflon bags		1.0 x 10 ²	45-150 ^{e/} (25° C)	9-16 ^{e/}	N	9
RTI	Al, Teflon film		2.7 x 10 ⁴	17-40 ^{f/}	10-26 ^{f/}	N	6
RTI	Al, Teflon film		2.7 x 10 ⁴	24-122 ^{g/}	9.5-39 ^{g/}	N	Current study

^{a/} Measured at approximately 1.0 ppm ozone.

^{b/} Artificial: A; natural sunlight: N, taken under sunny conditions unless stated otherwise.

^{c/} Range presented for simultaneous experiments conducted in two chambers in November and December of 1973.

^{d/} Experiments conducted in June of 1974.

^{e/} Half-lives varied over this range with water vapor concentration; experiments conducted in June of 1975.

^{f/} Range of half-lives from experiments conducted in 1975 and 1976.

^{g/} Range of half-lives from experiments conducted after May 1977 when original Teflon film was replaced; range reflects seasonal differences (see text and Table 6).

TABLE 8. NO OXIDATION IN RTI SMOG CHAMBERS

Date	% SS ^a	T _{max} ^b	Chamber 1		Chamber 2		Chamber 3		Chamber 4	
			[NO]i ^c	d/ R	[NO]i	R	[NO]i	R	[NO]i	R
7/15/77	Dark	---	0.79	1.6(1.2)	0.80	1.6(1.2)	0.80	1.5(1.3)	0.81	1.4(1.1)
7/15,16/77	Dark	---	0.62	1.9(1.4)	0.63	1.9(1.3)	0.61	2.0(1.4)	0.65	1.9(1.3)
7/15/77	77	35.0	0.68	0.3	0.69	0.4	0.70	0.6	0.71	0.3
7/16/77	76	35.6	0.51	1.3	0.52	0.8	0.52	1.6	0.53	0.9

^a/Duration of solar radiation reported as percent of possible minutes of direct sunshine (see text).

^b/Daily maximum temperature in °C.

^c/Initial [NO], in ppm.

^d/Ratio of experimentally determined second order rate constant for oxidation of NO to the established (literature) value $k_{\text{expt}}/k_{\text{lit}}$; ratios in parentheses have been corrected for chamber leakage; ratios not in parentheses have not been corrected for chamber leakage.

TABLE 9. LEAK RATE COEFFICIENTS IN RTI SMOG CHAMBERS BASED ON NO_x MEASUREMENTS

Date	% SS ^{b/}	T _{max} ^{c/}	Leak Rate Coefficient ^{a/}				Comment
			Chamber 1	Chamber 2	Chamber 3	Chamber 4	
7/15/77	Dark	---	0.0049	0.0043	0.0037	0.0042	Nighttime, NO expt.
7/15, 16/77	Dark	---	0.0065	0.0061	0.0056	0.0061	Nighttime, NO expt.
7/17/77	Dark	---	0.0053	0.0061	0.0050	0.0057	Nighttime, NO ₂ expt.
7/17, 18/77	Dark	---	0.0109	0.0087	0.0048	0.0046	Nighttime, NO ₂ expt.
7/15/77	77	35.0	0.0132(2.7) ^{d/}	0.0129(3.0)	0.0115(3.1)	0.0112(2.7)	Daytime, NO expt.
7/16/77	76	35.6	0.0164(2.5)	0.0147(2.4)	0.0161(2.9)	0.0147(2.4)	Daytime, NO expt.
7/17/77	79	35.0	0.0093(1.8)	0.0076(1.2)	0.0071(1.4)	0.0060(1.1)	Daytime, NO ₂ expt.
7/18/77	77	36.1	0.0149(1.4)	0.0109(1.3)	0.0138(2.9)	0.0111(2.4)	Daytime, NO ₂ expt.

^{a/}First order loss coefficient as determined from the slope of least squares regressions of $\ln$ [tracer] versus time data; the tracer is NO_x; units: hr⁻¹.

^{b/}Duration of solar radiation reported as percent of possible minutes of direct sunshine (see text).

^{c/}Daily maximum temperature in °C.

^{d/}The ratio of daytime to nighttime leak rate coefficients is enclosed by parentheses.

Loss rates of NO under irradiation in excess of the thermal rate may be attributed to participation of organic contaminants in the normal photochemical NO-oxidation reactions. Dimitriadis has suggested that the rate of NO loss under irradiated conditions provides a measure of chamber contamination levels.¹² Apparent second order rate constants for NO disappearance were determined by the technique noted above using data collected under irradiation. For these conditions, NO_x loss was much greater than under dark conditions. The data, however, do not permit correction of the apparent light-phase rate constants for leakage since the relative contributions of mechanical and chemical interactions to NO_x loss are currently undefined.

The uncorrected ratios of rate constants determined for irradiated conditions range from 0.3 to 1.6. These ratios compare favorably with those determined under dark conditions and with those reported previously for the RTI chambers.³ These results for the RTI chambers also compare reasonably well with the value of 4.0 for the Bureau of Mines chamber¹² and to values of 4.8 and 3.0 for the outdoor UNC facility.⁴

The behavior of NO_x in the RTI smog chambers was examined under two different sets of experimental conditions--the NO oxidation experiments discussed previously and experiments involving the irradiation of NO₂. If it is assumed that NO_x, comprised of both NO and NO₂, is relatively inert in a smog chamber in the absence of reactive organics, then leak rate coefficients may be determined using the same technique as that was described previously for the Freon-12 experiments. Leak rate coefficients calculated using NO_x as a tracer are presented in Table 9.

Nighttime leak rate coefficients ranged from 0.004 to 0.011 hr⁻¹ with a mean value of 0.0058 ± 0.0018 hr⁻¹. The daytime values ranged from 0.006 to 0.016 hr⁻¹ with a mean value of 0.012 ± 0.003 hr⁻¹. As shown previously for Freon-12, the daytime leak rate coefficients for NO_x are approximately twice as large as the nighttime values. In addition, since the NO_x leak rate coefficients are approximately equal for both the NO and the NO₂ experiments, NO_x loss does not appear to be sensitive to the relative amounts of NO or NO₂ that are present initially. The leak rate coefficients determined by NO_x loss, however, are generally higher than those determined by Freon-12 loss, and suggest that a mechanism in addition to leakage contributes to the loss of NO_x. Although increased daytime wind speeds may enhance the daytime

leak rate, gas-phase or surface-mediated reactions may lead to the formation of N_2O_5 and HNO_3 . The subsequent removal of these compounds on the chamber walls may also contribute to the apparent loss of NO_x . If a chemical mechanism were responsible for the apparent loss of NO_x , then such a mechanism would likely be manifest differently at the two NO/NO_2 ratios employed in these experiments. This, however, was not the case. Thus, the relative contributions of leakage and photo-initiated reaction sequences to the observed NO_x loss rates remain to be defined.

Sulfur dioxide is both a product and a reactant in the current study. Like ozone, SO_2 can disappear inside a chamber by interacting heterogeneously with the walls or by reacting homogeneously with contaminants present inside the chamber. Experiments were conducted to examine the stability of SO_2 in the RTI chambers under irradiation and in the dark. The results of these experiments are listed in Table 10.

On 31 August 1977 at 0100 EST, SO_2 was injected into the RTI chambers to an approximate initial concentration of 1.5 ppm. The water vapor concentration is estimated to have been 25000 ppm. By 0700 EST most of the SO_2 had disappeared. During the morning by approximately 1000 EST the $[\text{SO}_2]_{\text{max}}$ had increased slightly (10 to 15 ppb) in Chamber Nos. 1 and 3. At 1245 EST SO_2 was again injected; however, the newly injected SO_2 concentrations remained relatively stable until sunset. Filter samples collected during the afternoon could account for a maximum amount of particulate sulfur equivalent to only 20 ppb of SO_2 . After sunset, SO_2 decayed rapidly as it had done on the previous night. Filters collected during or shortly after both nighttime experiments could account for particulate sulfur equivalent to less than 10 ppb of SO_2 .

For the experimental conditions employed, SO_2 disappeared more rapidly at night than during the day--this behavior is the opposite of that displayed by ozone. Although nighttime SO_2 loss appears to be more complex than that of a first order process, such a process was nevertheless assumed, and half-lives were calculated. Estimates of dark phase half-lives ranged from 0.7 to 6.1 hours based on the August 1977 data and from 3.6 to 9.2 hours based on the March 1978 data. Daytime SO_2 loss rate followed a first order decay with half-lives of 17 to 26 hours in the August experiments and 9 to 12 hours in those conducted in March.

TABLE 10. SULFUR DIOXIDE DECAY IN RTI CHAMBERS

Date	% SS ^{a/}	T _{max} ^{b/}	Chamber 1		Chamber 2		Chamber 3		Chamber 4	
			[SO ₂] _i ^{c/}	t _d ^{d/}	[SO ₂] _i	t _d	[SO ₂] _i	t _d	[SO ₂] _i	t _d
8/31/77 ^{g/}	Dark	-	1.30	1.8	1.22	1.1	1.50 ^{e/}	2.2	1.06	0.7 ^{f/}
8/31, 9/1/77 ^{h/}	Dark	-	1.17	4.4	1.26	1.4	1.27	6.1	1.16	1.4 ^{f/}
3/2, 3/78 ^{i, j/}	Dark	-	0.71	5.6	0.82	9.2	0.77	7.4	-	-
3/3, 4/78 ^{k, l/}	Dark	-	0.63	3.6	0.74	6.6	0.65	5.1	-	-
8/31/77 ^{m/}	90	32.8	1.50	16.6	1.50	19.0	1.50	25.6	1.50	17.3 ^{f/}
3/3/78 ^{n, o/}	31	1.7	0.27	9.0	0.46	11.6	0.36	10.0	-	-

^{a/}Duration of solar radiation reported as percent of possible minutes of direct sunshine (see text).

^{b/}Daily maximum temperature in °C.

^{c/}Initial concentration of SO₂ in ppm.

^{d/}Half-life in hours: calculated from the slope of least squares regressions of ln[SO₂] versus time data.

^{e/}Concentration is greater than 1.5 ppm, exceeding the instrument's linear range and has been set to a default value of 1.50 ppm.

^{f/}Experiment was conducted in Chamber 4 with SO₂ added to ambient air that had not undergone prior purification.

^{g/}Experiment conducted from 0100 EST until 0700 EST.

^{h/}Experiment conducted from 1900 EST until 0200 EST.

^{i/}Characterization experiment conducted in a project subsequent to the present study.

^{j/}Experiment conducted from 2100 EST until 0500 EST.

^{k/}Experiment conducted from 1300 EST until 1900 EST.

^{l/}Experiment conducted from 0600 EST until 1700 EST.

Environmental factors such as relative humidity, temperature, and solar radiation may influence SO_2 behavior in smog chambers. A peripheral experiment in the current study examined the stability of SO_2 in a mixture with clean dry air contained in a 200 l Teflon bag under room lighting and temperature. The resulting 45 hour half-life is in good agreement with the dry dark phase half-life of 76 hours reported for a Tedlar bag.²² Other studies^{25 26} have shown the deposition velocity of SO_2 on gloss paint and on aluminum to increase by a factor of 30 as the relative humidity was increased from 20 to 80 percent. Although the literature is lacking on the effects of temperature and solar radiation on the interaction of SO_2 with various surfaces, two observations from the present study provide additional evidence linking environmental factors with the apparent SO_2 loss. First, the daytime loss rate was much smaller than the nighttime value. Secondly, following a nighttime loss of almost 1.5 ppm, the $[\text{SO}_2]_{\text{max}}$ increased slightly during midmorning. This, coupled with low particulate sulfur measurements, suggests that some of the SO_2 was deposited on the walls and that this deposition was not totally reversible. Although the mechanism by which SO_2 was lost remains to be defined, it is likely that the observed loss of SO_2 in the RTI chambers resulted from interactions with the chamber walls which may have been influenced by relative humidity, temperature, and solar radiation. Since these variables exhibit diurnal cycles, it is difficult to separate the effects of each variable on the apparent SO_2 behavior.

In addition to the above characterization experiments, matched experiments conducted during the experimental program show consistent behavior from chamber to chamber. For example, matched propene NO_x experiments were conducted on 8 August 1977. Mean initial conditions across the four chambers were: 1.43 ± 0.03 ppmC C_3H_6 and 0.59 ± 0.01 ppm NO_x (20 percent NO_2). The $\text{NO}-\text{NO}_2$ crossovers for the four chambers occurred within 19 minutes of each other at approximately 0643 EST, and the maximum NO_2 concentrations ranged from 0.46 to 0.49 ppm. Ozone concentration profiles from each of the four RTI chambers on 8 August 1977 are illustrated in Figure 8. The O_3 maxima on the first day of the experiment occurred between 1408 and 1518 EST and were in good agreement: 0.96, 0.96, 0.99, and 0.93 ppm. This agreement is consistent with that of previously reported matched experiments conducted in the RTI chambers³ and with simultaneous matched experiments conducted in

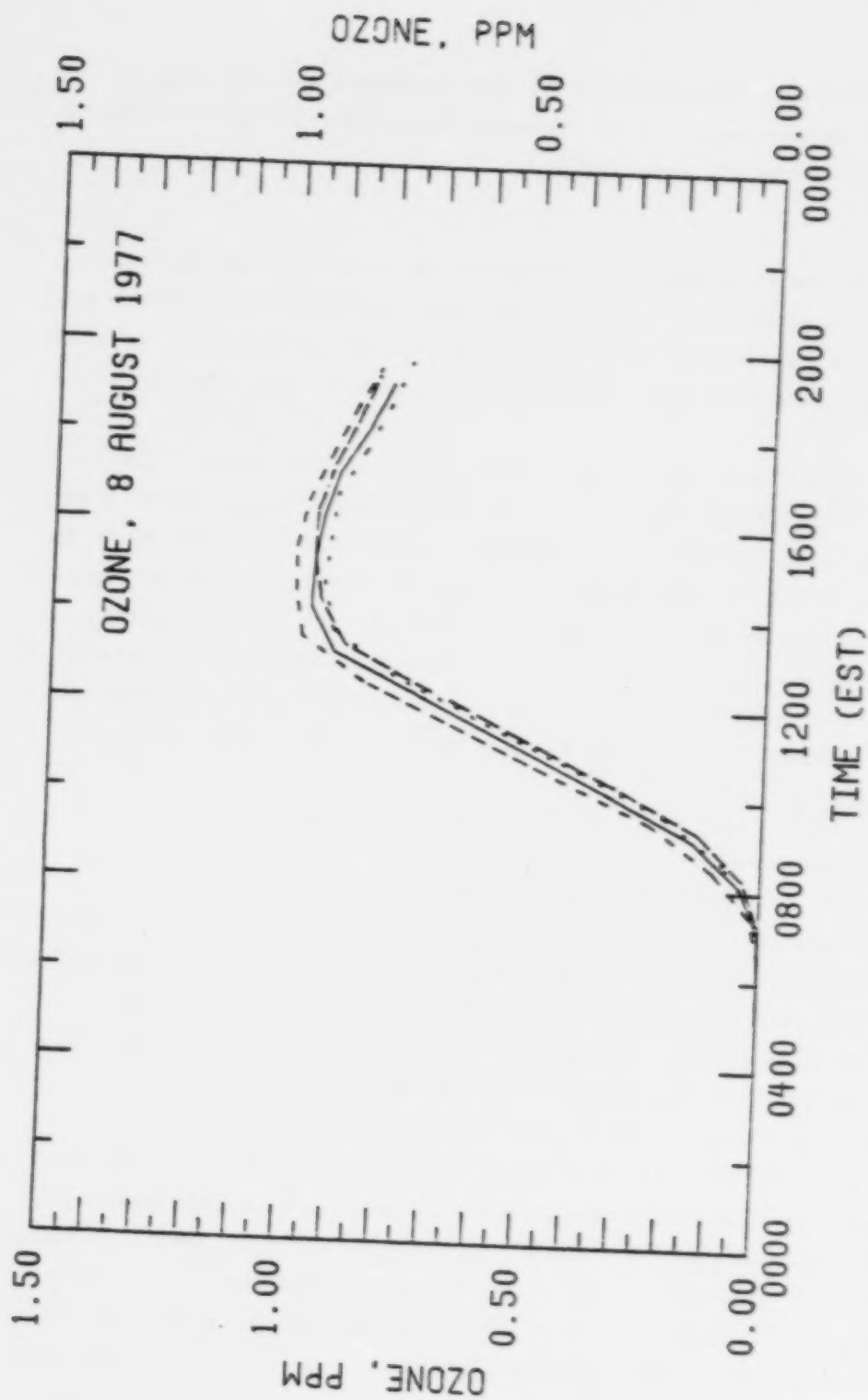


Figure 8. Ozone concentration-time profiles for matched propene-NO_x experiments conducted in the four RTI smog chambers on 8 August 1977. Initial conditions: 1.43 ppmC C₃H₆; 0.59 ppm NO_x (20 percent NO₂).

the RTI and UNC outdoor smog chambers.²⁷ The agreement demonstrated in these and other matched experiments increases confidence in the reliability of data obtained in the RTI smog chambers.

REAGENTS

Air used in the smog chamber experiments was supplied from the air purification systems that are located under each chamber. The other reagents used in this study are listed in Table 11. Additional information including molecular weight, boiling point, injection mode, purity, and supplier is also provided.

The O_2 that was used for O_3 injections was zero (Z-2) grade. The N_2 that was used to purge the injection lines was Matheson "Oxygen Free" grade. Nitrogen oxides were introduced from separate tanks that contained NO in N_2 and NO_2 in N_2 . The NO injection gas was prepared at RTI, and the NO_2 gas mixture was supplied by Scott. Single component gas and liquid reagents employed in this study were acquired from commercial suppliers with stated purities generally better than 95 percent. These single-component reagents were used as received from the suppliers without further purification.

MEASUREMENT METHODS

The measurement methods that were employed in the present study are described below. A summary of these methods is presented in Table 12.

Both automated and manual analytical techniques were employed. Ozone, nitrogen oxides, peroxyacetyl nitrate, hydrocarbons, Freon-12, sulfur dioxide, and total sulfur were monitored by automated instruments. Concentration data from each chamber were recorded hourly during the corresponding 10-minute sampling period. The reported O_3 , NO, and NO_2 concentrations were reduced from strip chart records at the eighth minute of each 10-minute sampling period. The PAN, HC, and sulfur analyzers are gas chromatographs. They were operated such that samples were injected at the eighth minute of each 10-minute sampling period. Manual operations were performed at various times during each experiment. These activities included the collection of filter samples for particulate sulfur determination and the determination of the number concentration of condensation nuclei. Total solar radiation and ambient temperature data were collected at one-minute intervals but were

TABLE 11. REAGENTS

Reagent	MW ^a / BP ^b	Injection ^c / Mode	Purity ^d / e/	Supplier
Oxygen, O ₂ (Z-2)	32	IS	99.95% ^e / 99.998% ^e / 659 ppm in N ₂ 110 ppm in N ₂	Scientific Gas Products
Nitrogen, N ₂ (Oxygen Free)	28	IS		Matheson
Nitric oxide, NO	30	IS		RTI Blend
Nitrogen dioxide, NO ₂	46	IS		Scott
Propene, C ₃ H ₆	42	G	99%	Phillips
Difluorodichloromethane, Cl ₂ CF ₂ (Freon-12)	121	G	NS	Virginia Chemical Co.
Sulfur dioxide, SO ₂	64	G	99.98%	Matheson
Hydrogen sulfide, H ₂ S	34	G	C.P.	Linde
Carbonyl sulfide, COS	60	G	97.5%	Matheson
Carbon disulfide, CS ₂	76	V	99+%	MD&B
Methanethiol, CH ₃ SH	48	G	99.5%	Matheson
Ethanethiol, C ₂ H ₅ SH	62	V	97%	Aldrich
Methyl sulfide, CH ₃ SCH ₃	62	V	98%	Aldrich
Methyl ethyl sulfide, CH ₃ SC ₂ H ₅	76	V	NS	K&K labs
Ethyl sulfide, C ₂ H ₅ SC ₂ H ₅	90	V	98%	Aldrich
Methyl disulfide, (CH ₃ S) ₂	94	V	NS	K&K labs
Ethyl disulfide, (C ₂ H ₅ S) ₂	122	V	NS	Aldrich
Thiophene, C ₄ H ₄ S	84	V	99+%	Aldrich
2-Methylthiophene, C ₅ H ₆ S	98	V	95%	Aldrich
3-Methylthiophene, C ₅ H ₆ S	98	V	98%	Aldrich
2, 5-Dimethylthiophene, C ₆ H ₈ S	112	V	98.5%	Aldrich

^a/Molecular weight.^b/Boiling point, °C; taken from Handbook of Chemistry and Physics.²⁸^c/Injection mode: IS--injection of gas via smog chamber injection system; G--direct injection of gas via N₂-purged line into chamber; V-Volatilization of liquid via heated injection manifold.^d/As designated by supplier; NS--not specified by supplier.^e/Contains less than 0.5 ppmC of total hydrocarbons.

TABLE 12. MEASUREMENT METHODS

Measured Quantity	Method	Manufacturer	Range	MDC ^{a/}
O ₃ Chemiluminescent	Bendix Model 8002	0-1 ppm	0.001 ppm	
NO, NO ₂ , NO _x	Chemiluminescent Model 14B	Thermo-Electron	0-1 ppm	0.001 ppm
Peroxyacetyl Nitrate (PAN) Electron Capture	Gas Chromatography/	Varian Model 1440	>1 ppb	1 ppb
Hydrocarbons (Propene) Flame Ionization	Gas Chromatography/ Model 8201	Modified Bendix	0-10 ppm (v/v)	0.005 ppm (v/v)
SO ₂ and Total Sulfur Flame Photometry	Gas Chromatography/	Tracor Model 270HA	0-1.5 ppm	0.03 ppm
Total Particulate Sulfur (TPS)	Filter Collection/ X-Ray Fluorescence	---	0-4000 µg/m ^{3b/}	5 µg/m ^{3b/}
Condensation Nuclei (CN) Nucleus Counter	Photoelectric Type CN	Gardner Associates,	0-10 ⁷ CN/cm ³	100 CN/cm ³
Freon-12 Spectroscopy	Long Path Infrared Miran I	Wilks Scientific (0-1 AU)	0-700 ppm	0.08 ppm
Solar Radiation ^{d/}	Pyranometer	Eppley Model 2 (cal/cm ²)	0-4 Langleys	---
Ambient Temperature ^{d,e/}	Thermistor	---	---	---
% Possible Sunshine ^{e/}	Photoelectric Cells	Foster Sunshine Switch	---	---

^{a/} Minimum detectable concentration as reported by the manufacturer.

^{b/} This value depends on sampling rate and duration.

^{c/} This value depends on the species and on sampling rate and duration.

^{d/} Data collected by the U.S. EPA, Division of Meteorology, Research Triangle Park, North Carolina.

^{e/} Data collected by NWS Forecast Office at RDU.²⁹

reported as hourly averages. The data from the measurements described above are reported in the appendix.

Ozone

Ozone was monitored with a Bendix Model 8002 Ozone Analyzer. The principle of operation employs the chemiluminescent gas-phase reaction between ozone and ethene. The instrument operates in the continuous mode with a range of 0 to 1 ppm and an MDC of 0.001 ppm. Calibration was performed prior to each experiment using a stable ultraviolet light ozone generator. The output of the O_3 generator was determined by gas-phase titration of O_3 with known NO concentrations that were blended from air and certified standard mixtures of NO in nitrogen.³⁰

Nitrogen Oxides (NO , NO_2 , and NO_x)

Nitrogen oxides were monitored with a Thermo-Electron (TECO) Model 14B NO - NO_x Analyzer. The principle of operation employs the chemiluminescent gas-phase reaction between NO and O_3 . Two modes of operation are required to determine NO, NO_2 , and NO_x . Nitric oxide is measured first using the reaction of NO and O_3 . The determination of NO_2 and NO_x , however, requires catalytic reduction of NO_2 to NO prior to the reaction of NO with ozone. The NO_x analyzer used in this study employed a molybdenum catalyst operated at 450° C to reduce NO_2 to NO. After reduction of NO_2 to NO, the signal from the total NO in the sample is taken to be the NO_x concentration. Electronic subtraction of the original NO signal from the NO_x signal yields the NO_2 concentration. The instrument operates with a 90-second cycle time: NO concentration is updated at the end of the first portion of the cycle, and NO_2 and NO_x concentrations are updated at the end of the cycle.

The instrument was calibrated prior to each experiment. Calibration of NO and NO_x channels was performed by dilution of a known concentration of NO from a certified cylinder of NO in nitrogen. Calibration of NO_2 was performed by using the NO_2 produced from the gas-phase titration of known NO concentrations with O_3 from the calibrated ozone generator.

The NO_x analyzer was usually operated on the 0 to 1 ppm full scale (FS) range, although both the 0 to 0.2 and the 0 to 0.5 ppm FS ranges were used occasionally. In contrast to the MDC of 0.001 ppm as specified by the manufacturer, the effective MDC in the current study was approximately 0.005 ppm

on the 0 to 1 ppm FS range. This is determined by instrument noise and the width of the strip chart trace. In addition, the zero baseline for the NO and the NO_x channels displayed a strong temperature dependence. Diurnal variations of the room temperature could produce as much as 10 percent FS shift in the zero baseline over the course of an experiment. Frequent zero checks reduced the impact of this behavior. The NO₂ channel did not exhibit this behavior because NO₂ is the difference between the NO_x and NO channels, which were both shifting by equal amounts.

It has been demonstrated that nitric acid, PAN, and ethyl nitrate interfere with NO₂ and NO_x determinations in instruments of the type employed in this study.^{31 32} It is anticipated that the interference is quantitative for most nitroxy compounds and that, to a first approximation, the chemiluminescent NO_x concentration is indicative of the concentration total gaseous nitroxy species that are delivered to the instrument. Although PAN, MN, and EN were determined in this study, the NO₂ and NO_x data were not corrected for these interferences.

During the course of the present study, many of the test species were found to interfere with the NO and NO₂ measurements. Immediately following the injection of an organo-sulfur compound into the chambers, positive step shifts in the NO readings and negative step shifts in the NO₂ readings were observed. Such shifts occurred even when NO_x had not yet been injected into the chambers. This and the rapidity of the shifts suggest that gas-phase chemical reactions within the chambers were not responsible for the observed behavior. Rather, it is hypothesized that the organo-sulfur species were acting as positive interferences for the NO measurements. It is further hypothesized that these test species were partially or totally destroyed as they passed through the instrument's catalytic converter (molybdenum at 450° C). This would have resulted in a reduced interference with the NO_x measurement in comparison to the interference with the NO measurement. Since the NO₂ reading is obtained by subtraction of the NO_x measurement from the NO measurement, the organo-sulfur species would appear as negative interferences for the NO₂ measurements.

The chemiluminescent reactions of ozone with organic sulfides have been investigated.^{33 34 35} The chemiluminescence emission spectra of H₂S, CH₃SH, and CH₃SCH₃ were found to display a broad structureless band that is centered

at approximately 340 nanometers. This band is associated with the decay of electronically excited SO_2 which is produced by the reaction of O_3 with an intermediate SO radical. However, it is doubtful that chemiluminescence in this band could be responsible for the interferences in the NO and NO_2 measurements. The NO_x analyzer has an optical filter positioned between the reaction chamber and the photomultiplier tube, which prevents the transmission of light at wavelengths below 600 nanometers. As a result, the instrument should not detect chemiluminescence emission spectra at 340 nanometers.

Weaker emission bands have been reported for H_2S , CH_3SH , and CH_3SCH_3 .³⁵ These emission bands for H_2S occurred between 520 and 810 nanometers. The emitting species was suggested to have been the excited HSO radical, which is produced by the reaction of O_3 with an intermediate SH radical. These emission bands may have been responsible for the interference due to H_2S . However, this does not account for the interference due to CH_3SH and CH_3SCH_3 , since the reaction of O_3 with these compounds does not produce SH radicals.³⁵ These reactions produce free hydrogen atoms, which react with O_3 to form vibrationally excited OH radicals. The Meinel band emission of these radicals extends from 550 nanometers to wavelengths longer than the 900-nanometer cutoff of the photomultiplier tube. Consequently, the Meinel band emission may have been responsible for the CH_3SH and CH_3SCH_3 interferences with the NO and NO_2 measurements.

The reaction of O_3 with thiophene has been found to produce a chemiluminescent emission spectrum similar to that of H_2S .³⁶ The interference due to thiophene may have been caused by the excited HSO radical.

To assess the magnitude of the interference, pure gas mixtures of the test species in zero air were analyzed using the NO_x instrument. First, 70-liter Teflon bags were filled with zero air. A sufficient quantity of one of the test species was injected into a bag to produce a 2 ppmC concentration. This bag was then connected to the sampling inlet of the instrument. The measurement of each test species was immediately preceded by a measurement of zero air to obtain an accurate value for the instrument's NO and NO_2 zero baseline. The results of this study are given in Table 13.

In most cases, the interference of the test species with the NO and NO_2 measurements was not serious. The interference equivalent exceeded 10 ppb

TABLE 13. NO AND NO₂ INTERFERENCE EQUIVALENTS FOR
2 ppmC OF EACH TEST SPECIES

Test Species	NO Interference Equivalent	NO ₂ Interference Equivalent
Hydrogen Sulfide	+ .004 ppm	- .004 ppm
Carbonyl Sulfide	+ .008 ppm	+ .001 ppm
Carbon Disulfide	.000 ppm	+ .001 ppm
Methanethiol	+ .017 ppm	- .017 ppm
Ethanethiol	+ .014 ppm	- .011 ppm
Methyl Sulfide	+ .007 ppm	- .003 ppm
Ethyl Sulfide	+ .014 ppm	- .008 ppm
Methyl Ethyl Sulfide	+ .006 ppm	- .003 ppm
Methyl Disulfide	+ .007 ppm	- .005 ppm
Ethyl Disulfide	+ .010 ppm	- .007 ppm
Thiophene	+ .002 ppm	- .001 ppm
2-Methylthiophene	+ .003 ppm	.000 ppm
3-Methylthiophene	+ .037 ppm	- .030 ppm
2,5-Dimethylthiophene	+ .005 ppm	- .004 ppm

for four species: methanethiol, ethanethiol, ethyl sulfide, and 3-methylthiophene. In the current study the interference was significant in those cases where the interference equivalent was large and the initial NO_x concentration was small (e.g., with 3-methylthiophene and an initial $[\text{NO}_x]$ of 0.1 ppm). In such cases, it is likely that the measured NO and NO_2 reaction profiles were significantly distorted from the actual profiles by the interference.

Interference-corrected estimates of the initial NO, NO_2 , and NO_x concentrations were made and are noted in the appendix. In the later stages of an experiment, interference corrections are difficult to establish due to the decreasing concentration of the interferent. Thus, the bulk of the NO, NO_2 , and NO_x data in the appendix have NOT been corrected for interference due to the test species.

Peroxyacetyl Nitrate

Peroxyacetyl nitrate (PAN) was monitored with a Varian Model 1440 Aerograph Gas Chromatograph equipped with a Sc^3H electron capture detector. A 1.8-m long by 2-mm ID glass column packed with 60 to 80 mesh Chromosorb W-HP coated with 10 percent Carbowax 400 was operated at room temperature. The carrier gas was 5 percent methane in argon. A Hewlett-Packard Model HP-3352 Laboratory Data System acquired the output signal, integrated peak areas, and converted the areas into concentration values that were printed by a teletype. Strip chart records of output signals were maintained to supplement data system records. The minimum detectable concentration is 1 ppb.

Sampling was controlled by a Carle Valve Minder II. Injections took place at 10-minute intervals and were synchronized with the overall chamber sampling cycle.

Elution times were adjusted in an attempt to prevent the water peak from one sample from interfering with the PAN measurement in the successive sample. This permitted the successful recovery of the majority of the PAN data.

The PAN calibration factor for those experiments conducted prior to 18 October (2.7×10^{-6} ppm/area count) was established by a multipoint calibration performed on this date. Calibration was performed by using gas mixtures of known PAN concentrations. Calibration mixtures were prepared by

EPA using a technique that involves the irradiation of a mixture of chlorine, acetaldehyde, and NO_2 .³⁷ Following the calibration, the instrument was modified, and its sensitivity was increased. Replicate experiments with methyl ethyl sulfide were conducted both before and after 18 October (on 10 October and 9 November). Since a PAN calibration factor was not performed after 18 October, the calibration (0.68×10^{-6} ppm/area count) was estimated based on the assumption of equivalent PAN production for the two sets of experiments conducted with methyl ethyl sulfide. The PAN data in the current study show consistent trends both within individual experiments and across different experiments conducted on the same day. Although the precision in the PAN data is good, the accuracy is uncertain. The estimated uncertainty in PAN concentrations is ± 50 percent for those experiments conducted before 18 October and may be as high ± 100 percent for those conducted after 18 October.

In several cases, two peaks were found in addition to PAN. They have been tentatively identified as methyl nitrate (MN) and ethyl nitrate (EN). These species were quantified based on PAN calibration factors. Since the MN and EN concentration data were erratic, daily median values were reported. The estimated uncertainty in MN and EN concentrations is ± 200 percent.

Propene

Propene was monitored with a modified Bendix Model 8201 Reactive Hydrocarbon Analyzer equipped with a flame ionization detector (FID). In its modified configuration, the instrument separates and quantifies individual hydrocarbon species in the C_1 to C_5 range. A 2.4-m long by 3.2-mm OD stainless steel column packed with 100 to 120 mesh Durapak Phenyl Isocyanate/Porasil C was operated at 30°C . The carrier gas was zero grade helium. Concentrations were calculated from area counts under individual peaks that were identified and measured by a Hewlett-Packard Model 3352 Laboratory Data System. Strip chart records of output signals were maintained to supplement data system records. The minimum detectable concentration is 5 ppb (v/v).

Sampling was controlled by a Carle Valve Minder II. Injections took place at 10-minute intervals and were synchronized with the overall chamber sampling cycle.

The instrument was calibrated prior to each propene run with a certified calibration mixture of propene in air that had been cross-compared with RTI calibration standards.

Sulfur Dioxide and Total Sulfur

Sulfur dioxide and other sulfur compounds were monitored with a Tracor Model 270 HA Atmospheric Sulfur Analyzer equipped with a flame photometric detector (FPD). Other sulfur-containing compounds were measured as total sulfur by direct injection of the sample to the FPD. Sulfur dioxide was detected following chromatographic separation. A 1.8-m long by 3.2-mm OD FEP Teflon column packed with a proprietary silica gel packing was operated at 60° C. The carrier gas was zero grade air. The electrometer output was linearized by an internal logarithmic amplifier. The instrument's response is linear over a range from 0 to approximately 1.5 ppm. Strip chart records of the chromatograms were maintained, and concentrations were determined from peak heights using an SO₂-air mixture as a reference. The minimum detectable SO₂ concentration is 0.03 ppm.

The sampling cycle was controlled by a Carle Valve Minder II. Injections took place at 10-minute intervals and were synchronized with the overall chamber sampling cycle.

The instrument was calibrated prior to each experiment. Calibration of the SO₂ peak heights was performed by dilution of a known concentration of SO₂ from a certified cylinder of SO₂ in air. Originally, the sulfur analyzer was employed to determine the concentration of only SO₂. During the analysis of the results, the peak heights of total sulfur and of individual sulfur species were used to permit estimates of reactant and product concentrations. In many cases reactant concentrations were estimated by the difference between the total sulfur and SO₂ peak heights. It should be noted that the response of the sulfur analyzer to sulfur-containing compounds other than SO₂ may not be equivalent to that for SO₂. Thus, the reported total sulfur, CH₃SH, COS, H₂S, and CS₂ concentration data should be considered only as qualitative indicators of the behavior of the gaseous sulfur species during any experiment.

Concentration data for SO₂, total sulfur, and other sulfur-species reported in the appendix contain default parameters that require identifica-

tion. For those cases in which no peaks were found, the corresponding concentrations are listed as 0.0. In several cases, peaks were identified but were too small to be quantified--these are set at 0.010. Since the response of the sulfur analyzer is not linear above 1.5 ppm, concentrations in excess of 1.5 ppm are listed as 1.500 ppm.

Total Particulate Sulfur

Total particulate sulfur (TPS) concentrations were determined by the collection of particulate samples on Teflon membrane filters with subsequent sulfur analysis by X-ray fluorescence. Sampling frequency varied from experiment to experiment. During a normal two-day experiment, 3 to 8 samples per day were collected at the manual sampling ports of each chamber.

The 37-mm diameter filters have a 1- μ m pore diameter and are mounted on 51-mm by 51-mm polyester filter frames. The filter holder is designed for in-line sampling through 4.6-mm OD Teflon tubing. Typically, air is pulled through the filter for a period of 15 minutes at a flowrate of 3 l/min. Sampling lines are short (0.5 m) to reduce particle deposition on the interior walls of the tubing.

The filters were analyzed by an energy-dispersive X-ray fluorescence spectrometer operated by EPA.³⁸ The detection limit for sulfur is reported as 29 ng/cm² of filter surface. This corresponds to a minimum detectable sulfur concentration of 5 μ g/m³ at the flow rate employed in the present study.

Condensation Nuclei

The number of condensation nuclei (CN) per cubic centimeter of sampled air was determined with a Gardner Associates Type CN Small Particle Detector. The principle of operation is the photoelectric measurement of water droplets that are formed by the condensation of supersaturated water vapor on small particles. The sampling frequency varied from experiment to experiment. Normally, CN determinations were performed from 3 to 8 times per day. The samples were taken directly at the manual sampling ports of each chamber through a 0.5-m length of 4.8-mm ID Teflon tubing. A short sampling line was used to reduce particle deposition on the interior walls of the tubing. Measurements conducted at two piston positions permit qualitative size

discrimination. Piston "position 1" permits the determination of CN having diameters greater than $0.26\text{ }\mu\text{m}$ while "position 5" corresponds to CN having diameters greater than $0.002\text{ }\mu\text{m}$. CN determinations were normally performed at piston "position 5". In most of the cases where measurements were conducted at two piston positions, there were no significant differences in the measured concentrations. Thus, only the CN concentration on data determined at piston "position 5" are reported in the appendix.

Instrument meter deflections were recorded in laboratory notebooks. Subsequently, the calibration curve provided by the manufacturer was used to convert the meter deflections into number concentration of CN. The CN data reported in the appendix should be considered to be qualitative indicators of the number of small particles within the chambers at a given time. Replicate determinations usually showed a precision of ± 20 percent, but comparison with other instruments of similar design showed agreement to within ± 50 percent.

Freon-12

Freon-12 (difluorodichloromethane) was used as a tracer in several experiments that were designed to quantify chamber leakage. It was monitored by a Wilks Miran I Variable Filter Infrared Analyzer. This instrument uses a single-beam spectrophotometer in conjunction with a 20-m variable pathlength White cell. When Freon-12 is present in the cell, the spectrum of infrared light will show a strong absorption band ($44\text{ atm}^{-1}\text{cm}^{-1}$ for 1 cm^{-1} resolution) at a spectral frequency of 930 cm^{-1} . Typical instrumental resolution in this spectral region is 20 cm^{-1} . The instrument is equipped with a linear absorbance accessory that produces an output signal proportional to the Freon-12 concentration. This signal was recorded on a strip chart recorder.

The Metal Bellows pump of the sampling system was used to flush air continuously through the White cell. This was accomplished by connecting the cell's intake port to the vent of the glass sampling manifold (see Figure 7).

Initial Freon-12 concentrations in the chambers were approximately 100 ppm. Bags also containing mixtures of approximately 100 ppm Freon-12 in air were prepared by injecting pure Freon-12 via a syringe into 100-liter bags that contained breathing air. Periodic span checks were made using these

mixtures. The instrument's zero was established during the ambient air portion of the sampling cycle.

Solar Radiation and Ambient Temperature

Total solar radiation and ambient air temperature data were collected by the U.S. Environmental Protection Agency, Division of Meteorology, at a point approximately 0.5 km from the RTI Smog Chamber Facility. The solar radiometer, an Eppley Precision Spectral Pyranometer, employs a thermopile sensing element and determines light intensity at wavelengths longer than 295 nm. Ambient air temperature was determined by a thermistor located in a gill aspirated temperature-radiation shield and is accurate to within $\pm 0.05^\circ \text{C}$.

Solar radiation and temperature were recorded at one-minute intervals by EPA's Data Acquisition System and were provided to RTI on magnetic tape. These data were read and converted to the hourly average values that appear in the appendix.

Environmental Variables

Other environmental variables reported in this study are the daily maximum temperature (T_{max}) and the percent of possible minutes of direct sunshine (% SS). The % SS is determined by a Foster Sunshine Switch, which consists of two photoelectric cells and a recorder. One cell is shaded from direct sunlight; the other is not. These cells are connected such that the recorder is actuated when the intensity of direct sunshine is sufficient to produce a shadow. The temperature and the sunshine data are collected by the National Weather Service (NWS) Forecast Office at the Raleigh-Durham Airport (RDU).²⁹ RDU is located approximately 10 km from the RTI Campus.

DATA COLLECTION AND HANDLING

The data handling system employed in the present study is composed of a sequence of manual and machine processing steps that are depicted in Figure 9. As a result of the number of parameters (e.g., O_3 , NO, NO_2 , etc.) being measured, their temporal density, and the diversity of their output formats, the data were introduced into the system at a time following the experiments rather than on a real-time basis. Raw data were manually transferred from some form of hard copy output onto computer cards. Calibration information

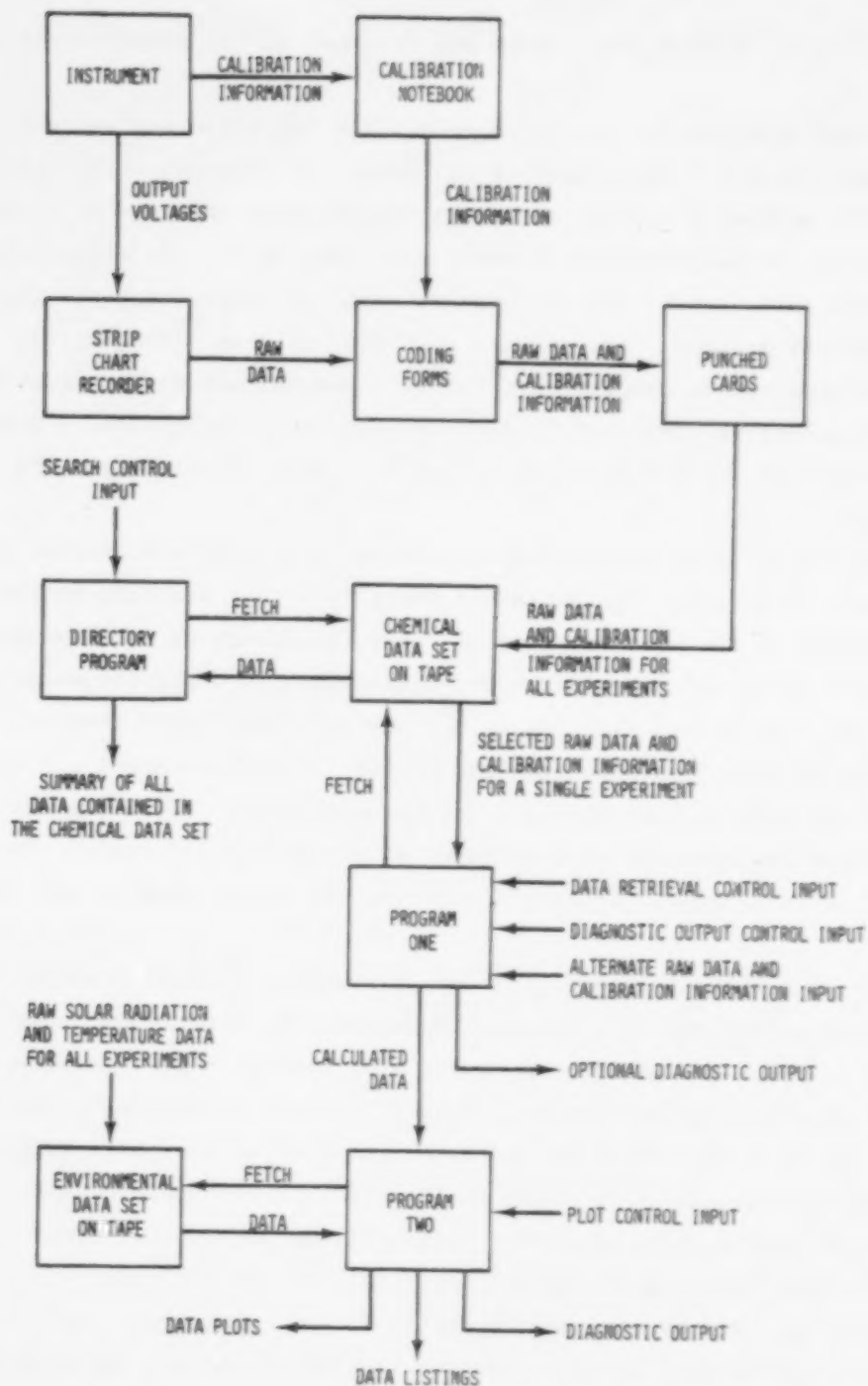


Figure 9. Flowchart of overall data handling system.

was also handled in this manner. Both are retained in the permanent records of the project.

The format in which the data were originally collected was dependent on the measurement method. The output of the ozone and nitrogen oxides instruments, and the automatic sulfur gas chromatograph, were recorded on strip chart recorders. A Hewlett-Packard Model 3352 Laboratory Data System with teletype output was used to collect data from the gas chromatographs that monitored PAN and propene. The results of EPA's analyses of the filter samples were reported on computer print-out. Condensation nuclei measurements were recorded in notebooks from instrument meter deflections. Total solar radiation and ambient air temperature data were obtained from EPA on magnetic tape.

In addition to their physical form, the raw data were also varied in their temporal structure. The automatic stepping of the sampling system from one chamber to the next resulted in the multiplexing of the measurements from the ozone and nitrogen oxides instruments, and the automatic gas chromatographs. Ozone and nitrogen oxides raw data were taken from the eighth minute of each 10-minute sampling period. One measurement per sampling period was made by the automatic gas chromatographs. Solar radiation and temperature measurements were recorded at one-minute intervals. Samples were collected at irregular intervals with the TPS filter sampler and the CN counter.

At the end of an experiment, all data pertaining to that experiment were organized and stored in a folder. Subsequently, the raw data were transferred to computer coding forms along with identifying information, such as the time and chamber number, which is associated with each measurement. The raw data were recorded in the units in which they were originally outputted (e.g., percent of recorder full scale). They remained in the multiplexed format in which they were originally measured. Calibration information which was used to convert the data from raw data units to concentration units was also entered on the coding forms. In general, several sets of coding forms were needed to record all the parameters which were measured in an experiment. This meant that parameters were handled by the computer as groups of parameters rather than as individual parameters or as an entire ensemble of measurements. During processing each parameter within

a group was identified by its SAROAD number (e.g., ozone $\equiv$ 44201). The information contained on the coding form was then keypunched onto cards. Either the cards or a magnetic tape, which was created from the cards, could be used as input for the data handling programs.

The data handling programs which were used in the current study were designed to maximize the use of calibration information while minimizing manual calculation and data manipulation. This approach helps insure the validity of the reported data. The calculation of parameter concentrations from the raw data is made possible by calibration subroutines in the programs. In addition to the advantages of storing the data in the rawest possible state, this also permits the calibration information to be modified without alteration of the data itself. The programs also have the capability of separating the multiplexed data by the chamber in which each measurement was made and of merging different groups of parameters into a single ensemble of measurements.

As is indicated in Figure 10, the raw data are converted into calculated data in concentration units by Program One. The first step in this process is the calculation of calibration values for each measurement. Since several parameters can experience calibration shifts over the course of a single experiment, error would result if a fixed calibration value were used. This problem is avoided by the calculation of linearly interpolated calibration values between measured calibration points. These interpolated calibration values are then used to convert the measurements to concentration units. In addition to employing routine zero-and-span type calibrations, Program One has the capability of handling more complex nonlinear calibration calculations and data validity assessments via special algorithms, which are tailored to individual parameters.

At this stage, the data are still multiplexed and are still separated into parameter groups. The final step of Program One is to demultiplex the data within each parameter group. The data are separated by chamber number and are put into chronological order. The data are then passed to Program Two and may also be placed in a data set for output by a digital plotter.

The purpose of Program Two is to reorganize further the data such that all the measurements for a particular chamber and time are merged into a single ensemble and then to output this reorganized data. This process is

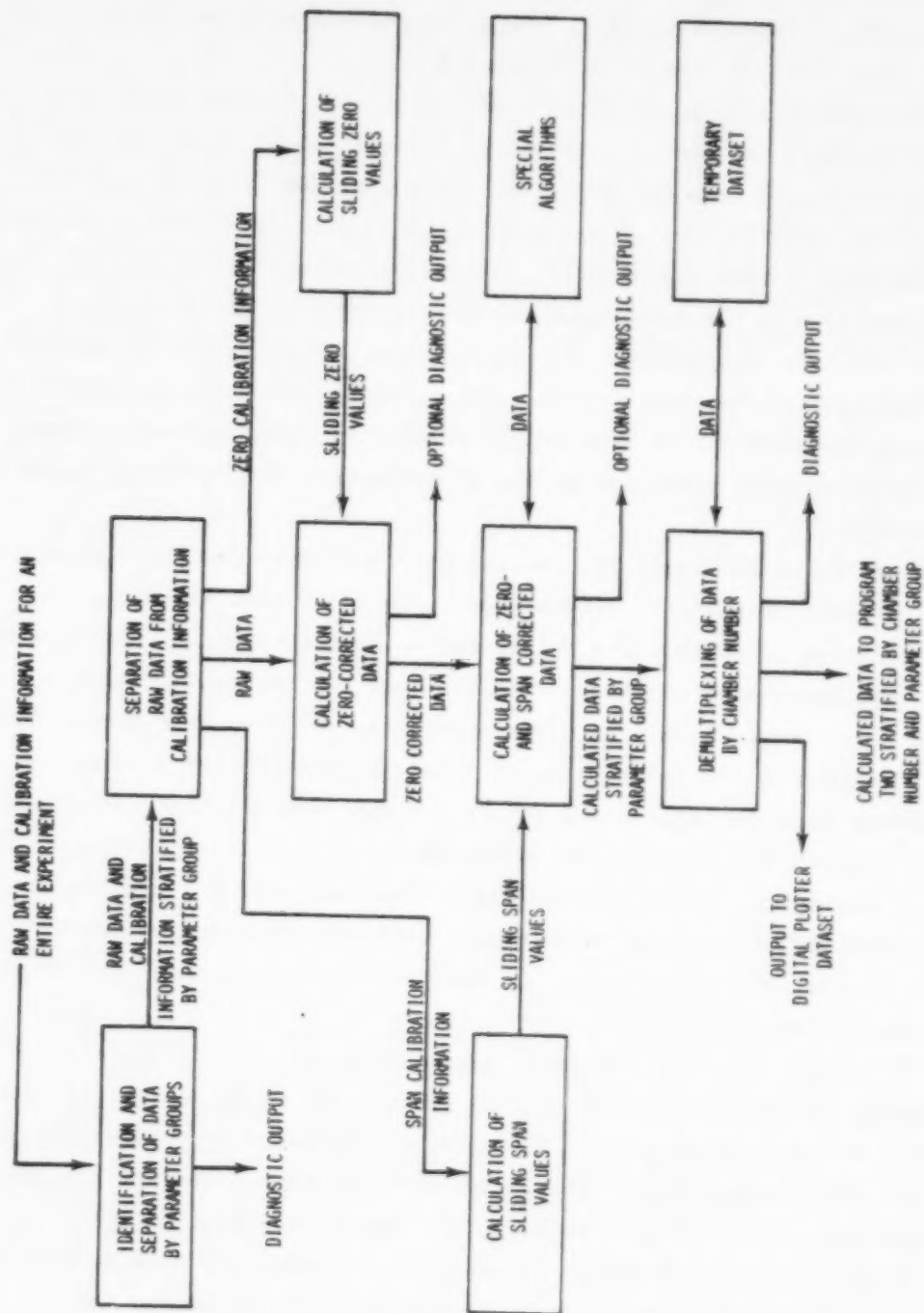


Figure 10. Flowchart of program one.

illustrated in Figure 11. Since different groups of measurements were made at different times, a common time base for all the parameter groups must be established. This is the first step in Program Two.

In the present study, the times of all the measurements have been adjusted to the time of the ozone measurement in the same whole hour. In general, the listed times correspond to the eighth minute of a sampling period. It should be noted that these data were converted by the Program One to fractional hours (EST). Since TPS and CN determinations involved manual operations, the times assigned to these measurements correspond to the automated instrument sampling period for the hour during which the manual measurement was performed.

The next step taken in Program Two is to merge all the data associated with a given time and chamber from the various parameter groups into a single ensemble of data. At this stage, the data is used to calculate derived parameter concentrations from the measured data. Examples of this feature are the calculation of NO_x concentrations from NO and NO_2 measurements, of time in fractional hours from time in hours and minutes, and of integrated light intensities (CU-SR) from instantaneous solar radiation measurements. The following formulae were used in these computations:

$$\text{NO}_x = \text{NO} + \text{NO}_2$$

$$\text{Time} = h + m/60$$

$$\text{CU-SR} = \sum_{i=0}^{h-1} \text{SR}(i) + \frac{m}{60} \text{SR}(h)$$

Where

$\text{SR}(i)$ is the average solar radiation for the i^{th} complete hour;

h is the number of the indicated hour; and

m is the number of minutes from the top of the indicated hour until the indicated time.

It should be noted that the SR data are listed in the appendix as hourly averages in units of Langleys per minute ($\text{cal cm}^{-2} \text{min}^{-1}$). The CU-SR is a measure of the cumulative solar radiation that had occurred up to the indicated time and is expressed in Langleys (cal cm^{-2}).

The final step in Program Two is the listing and plotting of the data on a line printer. In addition to listing the data in their final form, the two programs output various diagnostics data listings to facilitate verifica-

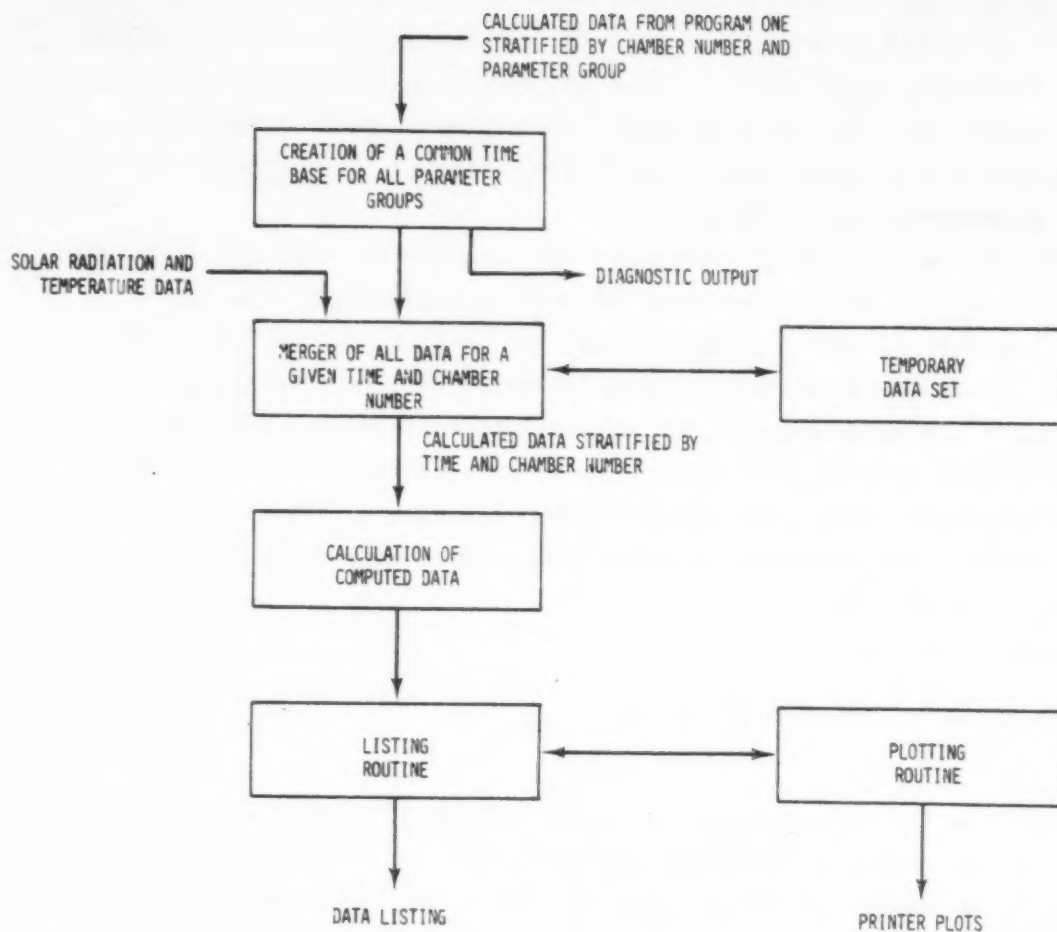


Figure 11. Flowchart of program two.

tion and correction of the data. In the present study, the data handling programs were normally used at least twice. Initially, listings and plots were generated to facilitate verification and correction of the data. Next, the final listings of the verified data were produced and are displayed in the appendix.

The data tabulated in the appendix contain default entries that require identification. Blank spaces indicate that data are not available. Measured zero values and negative outputs resulting from instrumental zero drift are designated as 0.0. Values measured to be greater than zero but less than 0.001 measurement units (usually ppm) are indicated by 0.000. In addition, special designations are used for the total sulfur and SO₂ data: concentrations too small to be quantified are listed as 0.010; and those concentrations that exceed the linear range of the instrument are set equal to 1.500.

PROCEDURE

The experiments conducted in the present study involved the irradiation of each of 14 organosulfur species in the presence of nitrogen oxides. The research plan was designed to investigate selected aspects of the chemical behavior of the sulfur-containing compounds under simulated atmospheric conditions. Two-day experiments were performed in the outdoor RTI Smog Chamber Facility described earlier. The chambers were operated in the static mode (no dilution) to simulate stagnation conditions. The procedure employed in these experiments is described in this subsection.

A normal two-day run involved only 36 hours of data collection--one dark and two daylight periods. Chamber preparation and air purification operations consumed the remaining time. A run was normally begun at 1700 EST when the previous run was terminated. The chambers were then purged at a flow rate of up to 2.3 m³ min⁻¹ for 1 to 2 hours. During this period the air purification unit was activated and achieved its normal operating temperatures and flow rates.

At approximately 1900 EST the purging operation was terminated, each chamber was sealed, and the cleanup operation was begun. Hydrocarbon and NO_x contaminants in the chamber air were removed by recirculation of the chamber contents through the air purification unit for approximately 8 hours at a flow rate of 0.28 m³ min⁻¹. In the present study the humidity of the

chamber contents was not altered during cleanup operations. This was accomplished by "bypassing" both the desiccant column and the humidifier during the cleanup.

At approximately 0300 EST, 2 to 3 hours before sunrise, the cleanup was terminated, and reactants were injected. Appropriate amounts of NO and NO₂ were introduced sequentially into each chamber from separate gas cylinders using the reactant injection system (see Figure 5). After the NO_x injection, the test species (the sulfur-containing compound or propene) was introduced into each chamber by syringe injection of the pure compound (for more details see the appropriate subsection). Injection operations were completed by approximately 1 hour before sunrise. This permitted time for mixing and initial reactant sampling prior to sunrise.

The contents of each chamber were sampled and monitored for the next 36 hours. Ozone, NO, NO₂, PAN, propene (when appropriate), total sulfur, and SO₂ were monitored once per hour for each chamber. Manual operations for TPS and CN determinations were performed periodically--normally 6 to 8 times during the first daylight period and 3 to 6 times during the second daylight period. Generally, each two-day run was terminated at 1700 EST on the afternoon of the second day.

SECTION 5

RESULTS AND DISCUSSION

OVERVIEW

The objective of the present study is to investigate selected aspects of the chemical behavior of 14 sulfur-containing compounds under atmospheric conditions simulated in smog chambers. A major goal is to examine the ozone production of each test compound under various initial conditions.

The experiments conducted in the present study are identified in Table 3 along with rough indicators of the environmental conditions that prevailed on each run day. Data collected during these experiments are presented in tabular form in the appendix.

In addition to propene, which was used as a control, the following compounds were examined:

H ₂ S	CH ₃ SH	CH ₃ SC ₂ H ₅	(C ₂ H ₅ S) ₂	3-Methylthiophene
COS	CH ₃ SCH ₃	C ₂ H ₅ SH	Thiophene	2,5-Dimethylthiophene
CS ₂	(CH ₃ S) ₂	C ₂ H ₅ SC ₂ H ₅	2-Methylthiophene	

Four experiments with each compound were conducted simultaneously in the four-chamber RTI facility described earlier. Target initial conditions were 2.0 ppmC of the test species and 0.1, 0.2, 0.5, and 1.0 ppm of NO_x (20 percent NO₂). Thus, each species was examined at target initial HC/NO_x ratios of 20, 10, 4, and 2 on the same days. For each compound this approach permits examination of the results of experiments conducted under identical environmental conditions but at different initial NO_x concentrations and hence at different initial HC/NO_x ratios.

The data are analyzed in two stages. First, the results of the same-day experiments conducted with each test compound are examined. These results are discussed for each compound separately. Next, selected reaction parameters for the 14 test species are intercompared. This permits a relative assessment among the test compounds of such reaction parameters as maximum ozone, sulfur dioxide, and particulate sulfur production.

EXAMINATION OF THE CHEMICAL BEHAVIOR OF EACH TEST COMPOUND

In this analysis results of the four experiments conducted with each test compound are examined. A tabular summary of selected reaction parameters is given for these experiments. A graphical display of concentration-time profiles of selected reactants and products for a representative experiment is also presented. Among the four experiments, the one that achieved the highest maximum ozone concentration is normally the one that was chosen for graphical presentation. These tabular and graphical results are used to identify and describe the effects that occurred when each test species was irradiated in the presence of different initial concentrations for NO_x .

In the examination of the behavior of each test species, observed trends are discussed. Since the target initial concentration of each test species was fixed and the initial NO_x concentrations were varied, trends can be interpreted to occur with either changing initial NO_x concentration or with changing initial HC/NO_x ratio. For example, if across four experiments the maximum ozone concentrations decrease with decreasing initial NO_x concentrations, then for a fixed initial test species concentration, they decrease with increasing initial HC/NO_x ratios. For conventional hydrocarbon species the photochemical reactivity as indicated by ozone production is sensitive to the initial HC/NO_x ratio. Although the choice was somewhat arbitrary, trends are identified and discussed in the current analysis with respect to target initial HC/NO_x ratios rather than initial NO_x concentrations.

Propene

Since propene has been investigated extensively in smog chambers over the past 10 to 15 years, it was employed as a control test species in the current study. Experiments were conducted near the beginning and again near the end of the current study period. Mixtures of propene and NO_x were irradiated on 12 and 13 September, on 11 and 12 November, and on 13 and 14 November 1977. Selected results from these experiments are summarized in Tables 14, 15, and 16. Concentration-time profiles for various reactants and products are presented in Figure 12 for the 12 September experiment conducted in Chamber No. 3.

In each of these experiments NO was oxidized rapidly to NO_2 . The duration of irradiation required to achieve NO- NO_2 crossover decreased with

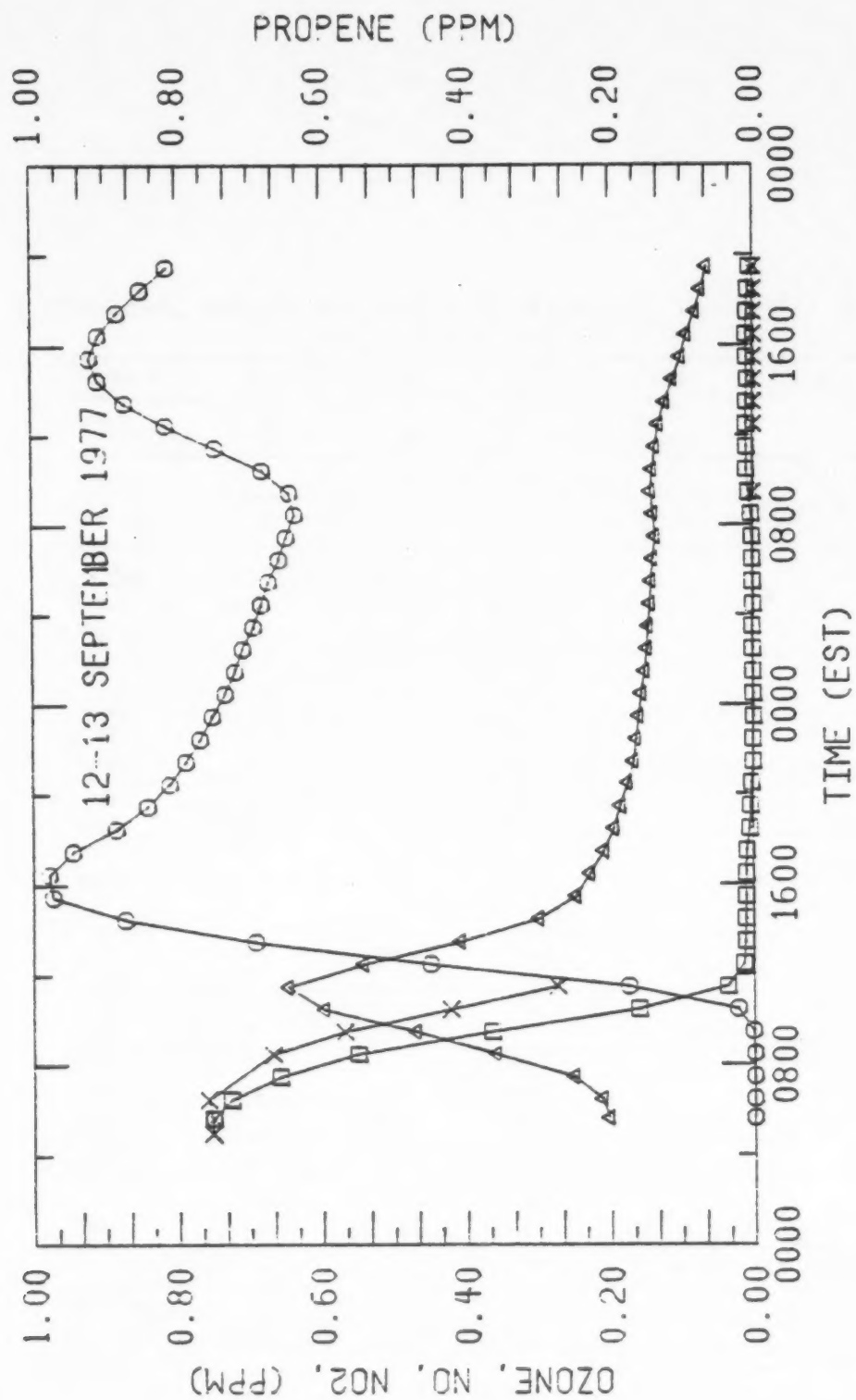


Figure 12. Concentration-time profiles of various reactants and products for the 12 and 13 September 1977 propene-NO_x experiment conducted in RTI Chamber No. 3. Target initial conditions: 2.0 ppmC C₃H₆ and 1.0 ppm NO_x. Symbol key: (o) O₃; (□) NO; (Δ) NO₂; and (x) C₃H₆.

TABLE 14. SUMMARY OF SELECTED RESULTS FROM SMOG CHAMBER EXPERIMENTS
CONDUCTED WITH PROPENE AND NO_x

TEST COMPOUND ^{a/}	DATE ^{b/}	T _{max} ^{c/}	%SS ^{d/}	CU-SR ^{e/}	SUNRISE ^{f/}
Propene, C ₃ H ₆	9-12-77 9-13-77	25.6 27.8	95 82	527 509	5.90
SMOG CHAMBER NUMBER		3	4	1	2
FIRST DAY PARAMETERS					
Target Initial HC/NO _x (ppmC/ppm)		2	4	10	20
Time of NO-NO ₂ Crossover, (hrs EST)		9.12	8.32	7.46	NA ^{2/}
[NO ₂] _{max} , ppm		0.648	0.358	0.145	0.058 ^{2/}
Time of [NO ₂] _{max} , (hrs EST)		11.47	9.63	8.13	8.30 ^{2/}
[O ₃] _{max} , ppm		0.978	0.968	0.604	0.344
Time of [O ₃] _{max} , (hrs EST)		16.47	15.63	16.13	16.30
[PAN] _{max} , ppm		ND	ND	ND	ND
Time of [PAN] _{max} , (hrs EST)		NA	NA	NA	NA
[MN] ppm ^{g/}		ND	ND	ND	ND
[EN] ppm		ND	ND	ND	ND
[NO _x] _{initial} ^{h/}		0.954	0.487	0.192	0.074 ^{2/}
[NO _x] @ 1700 EST		0.218	0.167	0.101	0.060
[NO _x] @ 1700 EST ^{i/}		0.229	0.343	0.526	0.811 ^{2/}
[C ₃ H ₆] @ 1700 EST ^{j/}		ND	ND	ND	ND
Time of [C ₃ H ₆] _k , (hrs EST) ^{k/}		10.11	10.76	9.39	10.15 ^{2/}
[SO ₂] _{max} , ppm		NA	NA	NA	NA
Time of [SO ₂] _{max} , (hrs EST)		NA	NA	NA	NA
[TPS] _{max} , µg/m ³		NA	NA	NA	NA
(ppmS)		NA	NA	NA	NA
Time of [TPS] _{max} , (hrs EST)		NA	NA	NA	NA
R ^{l/}		NA	NA	NA	NA
[CN] _{max} , cm ⁻³		950	620	430	3,300 ^{2/}
Time of [CN] _{max} , (hrs EST)		15.47	15.63	6.13	8.30 ^{2/}
Night-time O ₃ Half-Life (hrs) ^{m/}		33	34	24	20

(continued)

NOTES: Abbreviations: ND = no data are available; NA = not applicable;
0 = not detected; tr = detected, but not quantified; X = concen-
tration decreased, no maximum observed.

The appendix should be consulted for additional data that are not
summarized in this table.

TABLE 14. (continued)

SMOG CHAMBER NUMBER	3	4	1	2
SECOND DAY PARAMETERS				
$[O_3]_{\max}$, ppm	0.920	0.803	0.580	0.468
ΔO_3 , ppm ^{a/}	0.283	0.170	0.215	0.312
$[SO_2]_{\max}$, ppm	NA	NA	NA	NA
ΔSO_2 , ppm ^{a/}	NA	NA	NA	NA
$[TPS]_{\max}$, $\mu g/m^3$	NA	NA	NA	NA
(ppmS)	NA	NA	NA	NA
$[CN]_{\max}$, cm ⁻³	ND	ND	ND	ND

^{a/} Target initial concentration 2.0 ppmC or 0.67 ppm (V/V).

^{b/} Dates of first and second days of the experiment.

^{c/} Daily maximum temperature in °C.²⁹

^{d/} Duration of direct solar radiation reported as percent of possible minutes of sunshine.²⁹

^{e/} Cumulative daily solar radiation expressed in Langleys ($cal\ cm^{-2}$); note that the second-day value is the cumulative solar radiation on that day until the experiment was terminated--usually 1700 EST.

^{f/} Time of sunrise in hours (EST); since the times of sunrise are approximately the same for both days, the time is given for the first day only.

^{g/} Daily median concentrations of species tentatively identified to be methyl and ethyl nitrate; they are not listed in the appendix.

^{h/} The initial $[NO_x]$ is taken to be the concentration that existed at approximately the time of sunrise^x; the table entry has NOT been corrected for possible interferences.

^{i/} Fraction of initial NO_x remaining at the 1700 EST hour calculated from NO_x concentrations as determined by^x the chemiluminescent NO_x analyzer.

^{j/} Fraction of accountable test compound at the 1700 EST hour.

^{k/} Estimate of the time at which approximately one-half of the test compound was consumed.

^{l/} Ratio of product sulfur as particulate to the total accountable reacted sulfur at the time of $[SO_2]_{\max}$: $([TPS]/([TPS]+[SO_2]))$.

^{m/} Estimate of ozone half-life based on data collected during the 2000 EST hour of the first day and the 0400 EST hour of the second day: $t_{1/2} \approx 5.545/\ln ([O_3]_{2000}/[O_3]_{0400})$.

^{n/} This half-life may be suspect, since ozone concentrations smaller than 0.1 ppm were involved in its determination.

^{o/} Net concentration on the second day is the difference between the second-day maximum concentration and the preceding minimum concentration: $\Delta O_3 = [O_3]_{\max} - [O_3]_{\min}$ and $\Delta SO_2 = [SO_2]_{\max} - [SO_2]_{\min}$.

^{p/} Due to an operational problem during reactant injection, the initial concentrations in Chamber No. 2 are not clearly defined; these tabulated results should be considered with caution.

TABLE 15. SUMMARY OF SELECTED RESULTS FROM SMOG CHAMBER EXPERIMENTS
CONDUCTED WITH PROPENE AND NO_x

TEST COMPOUND ^{a/}	DATE ^{b/}	$\tau_{\max}^c/$	$\%SS^d/$	CU-SR ^{e/}	SUNRISE ^{f/}
Propene, C ₃ H ₆	11-11-77	13.3	100	331	6.88
	11-12-77	8.9	83	316	
SMOG CHAMBER NUMBER		4	3	2	1
FIRST DAY PARAMETERS					
Target Initial HC/NO _x (ppmC/ppm)		2	4	10	20
Time of NO-NO ₂ Crossover, (hrs EST)		10.92	9.78	9.01	8.74
[NO ₂] _{max} , ppm		0.639	0.371	0.145	0.065
Time of [NO ₂] _{max} , (hrs EST)		14.63	11.47	10.30	10.13
[O ₃] _{max} , ppm		0.043	0.446	0.393	0.266
Time of [O ₃] _{max} , (hrs EST)		14.63	14.47	12.30	11.13
[PAN] _{max} , ppm		0.024	0.078	0.042	0.021
Time of [PAN] _{max} , (hrs EST)		16.63	16.47	17.30	16.13
[MN] ppm ^{g/}		0.003	0.001	tr	tr
[EN] ppm		0	0	0	tr
[NO] _x initial ^{h/}		0.956	0.482	0.186	0.090
[NO] _x @ 1700 EST		0.632	0.157	0.087	0.046
ENO _x @ 1700 EST ^{i/}		0.661	0.326	0.468	0.511
fC ₃ H ₆ @ 1700 EST ^{j/}		0.28	0.04	0.06	0.17
Time of [C ₃ H ₆] _k , (hrs EST) ^{k/}		13.11	11.96	11.08	11.12
[SO ₂] _{max} , ppm		NA	NA	NA	NA
Time of [SO ₂] _{max} , (hrs EST)		NA	NA	NA	NA
[TPS] _{max} , $\mu\text{g}/\text{m}^3$ (ppmS)		NA	NA	NA	NA
Time of [TPS] _{max} , (hrs EST)		NA	NA	NA	NA
R ^{l/}		NA	NA	NA	NA
[CN] _{max} , cm ⁻³		950	320	950	2,600
Time of [CN] _{max} , (hrs EST)		14.63	14.47	14.30	13.13
Night-time O ₃ Half-Life (hrs) ^{m/}		NA	41	22	9 ^{n/}

(continued)

NOTES: Abbreviations: ND = no data are available; NA = not applicable;
0 = not detected; tr = detected, but not quantified; X = concen-
tration decreased, no maximum observed.

The appendix should be consulted for additional data that are not
summarized in this table.

TABLE 15. (continued)

SMOG CHAMBER NUMBER	4	3	2	1
SECOND DAY PARAMETERS				
$[O_3]_{\max}$, ppm	0.169	X	X	0.051
ΔO_3 , ppm ^{a/}	0.169	NA	NA	0.018
$[SO_2]_{\max}$, ppm	NA	NA	NA	NA
ΔSO_2 , ppm ^{a/}	NA	NA	NA	NA
$[TPS]_{\max}$, $\mu g/m^3$	NA	NA	NA	NA
(ppmS)	NA	NA	NA	NA
$[CN]_{\max}$, cm^{-3} g/	620	460	730	2500

^{a/} Target initial concentration 2.0 ppmC or 0.67 ppm (V/V).

^{b/} Dates of first and second days of the experiment.

^{c/} Daily maximum temperature in °C.²⁸

^{d/} Duration of direct solar radiation reported as percent of possible minutes of sunshine.²⁹

^{e/} Cumulative daily solar radiation expressed in Langleys ($cal\ cm^{-2}$); note that the second-day value is the cumulative solar radiation on that day until the experiment was terminated--usually 1700 EST.

^{f/} Time of sunrise in hours (EST); since the times of sunrise are approximately the same for both days, the time is given for the first day only.

^{g/} Daily median concentrations of species tentatively identified to be methyl and ethyl nitrate; they are not listed in the appendix.

^{h/} The initial $[NO_x]$ is taken to be the concentration that existed at approximately the time of sunrise; the table entry has NOT been corrected for possible interferences.

^{i/} Fraction of initial NO_x remaining at the 1700 EST hour calculated from NO_x concentrations as determined by the chemiluminescent NO_x analyzer.

^{j/} Fraction of accountable test compound at the 1700 EST hour.

^{k/} Estimate of the time at which approximately one-half of the test compound was consumed.

^{l/} Ratio of product sulfur as particulate to the total accountable reacted sulfur at the time of $[SO_2]_{\max}$: $(([TPS]/([TPS]+[SO_2])))$.

^{m/} Estimate of ozone half-life based on data collected during the 2000 EST hour of the first day and the 0400 EST hour of the second day: $\tau_{1/2} \approx 5.545/\ln ([O_3]_{2000}/[O_3]_{0400})$.

^{n/} This half-life may be suspect, since ozone concentrations smaller than 0.1 ppm were involved in its determination.

^{o/} Net concentration on the second day is the difference between the second-day maximum concentration and the preceding minimum concentration: $\Delta O_3 = [O_3]_{\max} - [O_3]_{\min}$ and $\Delta SO_2 = [SO_2]_{\max} - [SO_2]_{\min}$.

^{p/} Since second-day CN concentrations were recorded only once for each chamber, these data do not truly represent maximum values.

TABLE 16. SUMMARY OF SELECTED RESULTS FROM SMOG CHAMBER EXPERIMENTS CONDUCTED WITH PROPENE AND NO_x

TEST COMPOUND ^{a/}	DATE ^{b/}	T _{max} ^{c/}	XSS ^{d/}	CU-SR ^{e/}	SUNRISE ^{f/}
Propene, C ₃ H ₆	11-13-77 11-14-77	7.8 10.6	100 89	340 293	6.92
SMOG CHAMBER NUMBER		4	3	2	1
FIRST DAY PARAMETERS					
Target Initial HC/NO _x (ppmC/ppm)		2	4	10	20
Time of NO-NO ₂ Crossover, (hrs EST)		11.36	10.12	9.28	8.83
[NO ₂] _{max} PPM		0.607	0.361	0.151	0.076
Time of [NO ₂] _{max} , (hrs EST)		14.63	12.47	10.30	10.13
[O ₃] _{max} PPM		0.018	0.318	0.360	0.247
Time of [O ₃] _{max} , (hrs EST)		14.63	15.47	12.30	12.13
[PAN] _{max} PPM		0.018	0.061	0.043	0.023
Time of [PAN] _{max} , (hrs EST)		16.63	16.47	15.30	17.13
[NO] ppm ^{g/}		0.002	0.002	tr	0
[EN] ppm		0	0	tr	0
[NO] _x initial ^{h/}		0.970	0.491	0.200	0.102
[NO] _x @ 1700 EST		0.726	0.124	0.084	0.045
ENO _x @ 1700 EST ^{i/}		0.748	0.253	0.420	0.441
HC ₃ H ₆ @ 1700 EST ^{j/}		ND	ND	ND	ND
Time of [C ₃ H ₆] _{max} , (hrs EST) ^{k/}		14.29	12.92	11.67	11.53
[SO ₂] _{max} PPM		NA	NA	NA	NA
Time of [SO ₂] _{max} , (hrs EST)		NA	NA	NA	NA
[TPS] _{max} µg/m ³ (ppm)		NA	NA	NA	NA
Time of [TPS] _{max} , (hrs EST)		NA	NA	NA	NA
R ^{l/}		NA	NA	NA	NA
[CN] _{max} cm ⁻³		280	320	460	1,400
Time of [CN] _{max} , (hrs EST)		11.63	11.47	11.30	11.13
Night-time O ₃ Half-life (hrs) ^{m/}		NA	27	25	11 ^{n/}

NOTES: Abbreviations: ND = no data are available; NA = not applicable; 0 = not detected; tr = detected, but not quantified; X = concentration decreased, no maximum observed.

The appendix should be consulted for additional data that are not summarized in this table.

(continued)

TABLE 16. (continued)

SMOG CHAMBER NUMBER	4	3	2	1
SECOND DAY PARAMETERS				
$[O_3]_{\max}$, ppm	0.138	X	X	X
ΔO_3 , ppm ^{a/}	0.138	NA	NA	NA
$[SO_2]_{\max}$, ppm	NA	NA	NA	NA
ΔSO_2 , ppm ^{a/}	NA	NA	NA	NA
$[TPS]_{\max}$, $\mu\text{g}/\text{m}^3$ (ppmS)	NA	NA	NA	NA
$[CN]_{\max}$, cm^{-3}	650	0	200	200

^{a/} Target initial concentration 2.0 ppmC or 0.67 ppm (V/V).

^{b/} Dates of first and second days of the experiment.

^{c/} Daily maximum temperature in $^{\circ}\text{C}$.²⁹

^{d/} Duration of direct solar radiation reported as percent of possible minutes of sunshine.²⁹

^{e/} Cumulative daily solar radiation expressed in Langley's (cal cm^{-2}); note that the second-day value is the cumulative solar radiation on that day until the experiment was terminated--usually 1700 EST.

^{f/} Time of sunrise in hours (EST); since the times of sunrise are approximately the same for both days, the time is given for the first day only.

^{g/} Daily median concentrations of species tentatively identified to be methyl and ethyl nitrate; they are not listed in the appendix.

^{h/} The initial $[NO]_x$ is taken to be the concentration that existed at approximately the time of sunrise; the table entry has NOT been corrected for possible interferences.

^{i/} Fraction of initial NO_x remaining at the 1700 EST hour calculated from NO_x concentrations as determined by the chemiluminescent NO_x analyzer.

^{j/} Fraction of accountable test compound at the 1700 EST hour.

^{k/} Estimate of the time at which approximately one-half of the test compound was consumed.

^{l/} Ratio of product sulfur as particulate to the total accountable reacted sulfur at the time of $[SO_2]_{\max}$: $([TPS]/([TPS]+[SO_2]))$.

^{m/} Estimate of ozone half-life based on data collected during the 2000 EST hour of the first day and the 0400 EST hour of the second day: $t_{1/2} \approx 5.545/\ln([O_3]_{2000}/[O_3]_{0400})$.

^{n/} This half-life may be suspect, since ozone concentrations smaller than 0.1 ppm were involved in its determination.

^{o/} Net concentration on the second day is the difference between the second-day maximum concentration and the preceding minimum concentration: $\Delta O_3 = [O_3]_{\max} - [O_3]_{\min}$ and $\Delta SO_2 = [SO_2]_{\max} - [SO_2]_{\min}$.

increasing initial HC/NO_x ratios (i.e., the rate of conversion increased with decreasing initial NO_x concentrations). The photooxidation of NO to NO₂ proceeded more rapidly in the September experiments than in those conducted in November. For the slowest case, a target initial HC/NO_x ratio of 2, crossover occurred after approximately 3.2 hours of irradiation at 0907 EST on 12 September; however, at the same initial conditions, crossover occurred approximately 4.2 hours after sunrise at 1055 and 1121 EST on 11 and 13 November.

Ozone accumulated during each experiment, maximum concentrations were dependent on the initial HC/NO_x ratio. The maximum ozone concentration, 0.98 ppm, was produced on 12 September at a target HC/NO_x ratio of 2. Maximum concentrations of 0.45 and 0.36 ppm occurred on 11 and 13 November at target HC/NO_x ratios of 4 and 10 respectively. Although the [O₃]_{max} generally occurred during the 1600 hour in the September experiments irrespective of initial conditions, in November the [O₃]_{max} occurred during the 1400 hour at low HC/NO_x ratios and two to three hours earlier at the higher ratios.

Both the decrease in the absolute values of the maximum ozone concentrations and the shift from occurring at a low HC/NO_x ratio to higher ratios were probably caused by environmental differences. The temperature, the sunlight intensity, and the duration of sunshine were greater for the September than for the November experiments. On 12 September the cumulative daily solar radiation was 527 cal cm⁻² with 95 percent of the possible minutes of direct sunshine, and a maximum temperature of 25.6° C. Both 11 and 13 November were 100 percent sunshine days and had comparable cumulative daily solar radiation data--331 and 340 cal cm⁻². The maximum temperature of 13.3° C on 11 November was 5.5° warmer than that on 13 November and may have been responsible for the slight enhancement of such reactivity parameters as time to NO-NO₂ crossover and [O₃]_{max} on 11 versus 13 November. This, however, is somewhat speculative, since the absolute propene concentrations were on the average 13 percent higher on 11 November than on 13 November.

The PAN data for the November experiments suggest that the conditions which result in the production of high maximum concentrations of ozone also lead to the production of high concentrations of PAN. High yields of PAN were produced at high HC/NO_x ratios. In addition, peaks tentatively identi-

fied as methyl nitrate (MN) were found. Although never more than a few ppb, the highest concentrations of MN occurred at low initial HC/NO_x ratios (high initial NO_x concentrations). Ethyl nitrate (EN) concentrations were detected in only two of the eight experiments and these concentrations were low.

Inspection of the first-day NO_x data in the appendix revealed unusual behavior for the three sets of propene-NO_x experiments. Generally, at the two highest initial HC/NO_x ratios, between 0900 and 1400 EST, the NO_x concentration exhibited a loss of a few ppb and a subsequent recovery. The timing of this phenomenon coincided with the initial buildup of PAN. This behavior was not observed in the remaining two experiments, although it may have been obscured by the higher NO_x concentrations employed in these experiments. It is likely that a transient nitrogen-containing species was responsible for this behavior. This species was either not delivered to the NO_x monitor as a result of interactions with chamber walls or the sampling system, or it could not be detected by the chemiluminescent NO_x monitor that was employed. At any rate, the identity of this hypothetical species is unknown.

A nitrogen mass balance was estimated for each experiment based on chemiluminescent NO_x concentrations determined initially and again during the 1700 EST hour of the first day. In general, the nitrogen balance was the poorest for those conditions under which high ozone concentrations were generated. Typically, only 0.25 to 0.40 of the initial NO_x could be accounted for at optimum ozone-generative conditions, while up to 0.75 could be accounted for at other conditions. The unaccountable product nitrogen is presumably comprised of nitric acid or other undetermined nitrogen-containing species that may be in the gas phase or on the walls of the chamber. The fate of NO_x in photochemically reacting systems is largely unknown and should be investigated.

Propene was consumed rapidly during these experiments. Estimates were made of the fraction of C₃H₆ that remained unreacted at the 1700 EST hour. These results as well as the times to one-half consumption of C₃H₆ suggest that the C₃H₆ disappearance rate was dependent on the initial HC/NO_x ratio. For the four experiments conducted on 11 November, the fraction of initial C₃H₆ that remained ranged from 0.04 to 0.28. The experiment in which reaction of propene was most nearly complete also produced the highest maximum ozone concentrations. The ordering of the accountable fraction of C₃H₆ was

similar to that observed earlier for the other reactant-- NO_x . These results suggest that for the propene- NO_x systems employed in the current study, the conditions under which the maximum fraction of each reactant is consumed coincides with maximum reactivity as measured by ozone production.

The photooxidation of propene did not produce large numbers of condensation nuclei. Maximum CN levels were generally less than 3000 cm^{-3} and displayed no apparent trends with HC/NO_x ratio.

High ozone concentrations approaching the first-day maximum concentrations were achieved on the second day during the September experiments in three of four cases. At the target HC/NO_x ratio of 20, the second-day maximum ozone concentration exceeded the first-day value. The net ozone concentrations generated were less than the first-day maxima and ranged from 0.17 to 0.31 ppm. During the November experiments at HC/NO_x ratios of 4, 10, and 20, second-day ozone concentrations generally decayed from the first-day maxima. At the HC/NO_x ratio of 2, however, excessive initial NO_x under light-limited conditions yielded little ozone on the first day. By the second day most of the initial NO had been converted to NO_2 , the system was no longer light-limited, and significant amounts of ozone were produced. Second-day maximum and net ozone concentrations were identical. These values were 0.17 on 12 November and 0.14 ppm on 14 November. In addition, the target HC/NO_x ratio of 2 was the only condition where second-day net ozone concentrations exceeded the first-day maximum concentrations for C_3H_8 - NO_x systems, and this only occurred in the November experiments.

Hydrogen Sulfide

Mixtures of hydrogen sulfide and NO_x were irradiated on 23 and 24 September 1977. On 23 September the cumulative daily solar radiation was 421 cal cm^{-2} with 51 percent of the possible minutes of direct sunshine and a maximum temperature of 26.7° C . Selected results from the H_2S - NO_x experiments are summarized in Table 17. Concentration-time profiles of various reactants and products for the experiment conducted in Chamber No. 3 are presented in Figure 13.

The photochemical behavior of irradiated mixtures of NO_x and H_2S was markedly different from that of irradiated mixtures of NO_x and a hydrocarbon

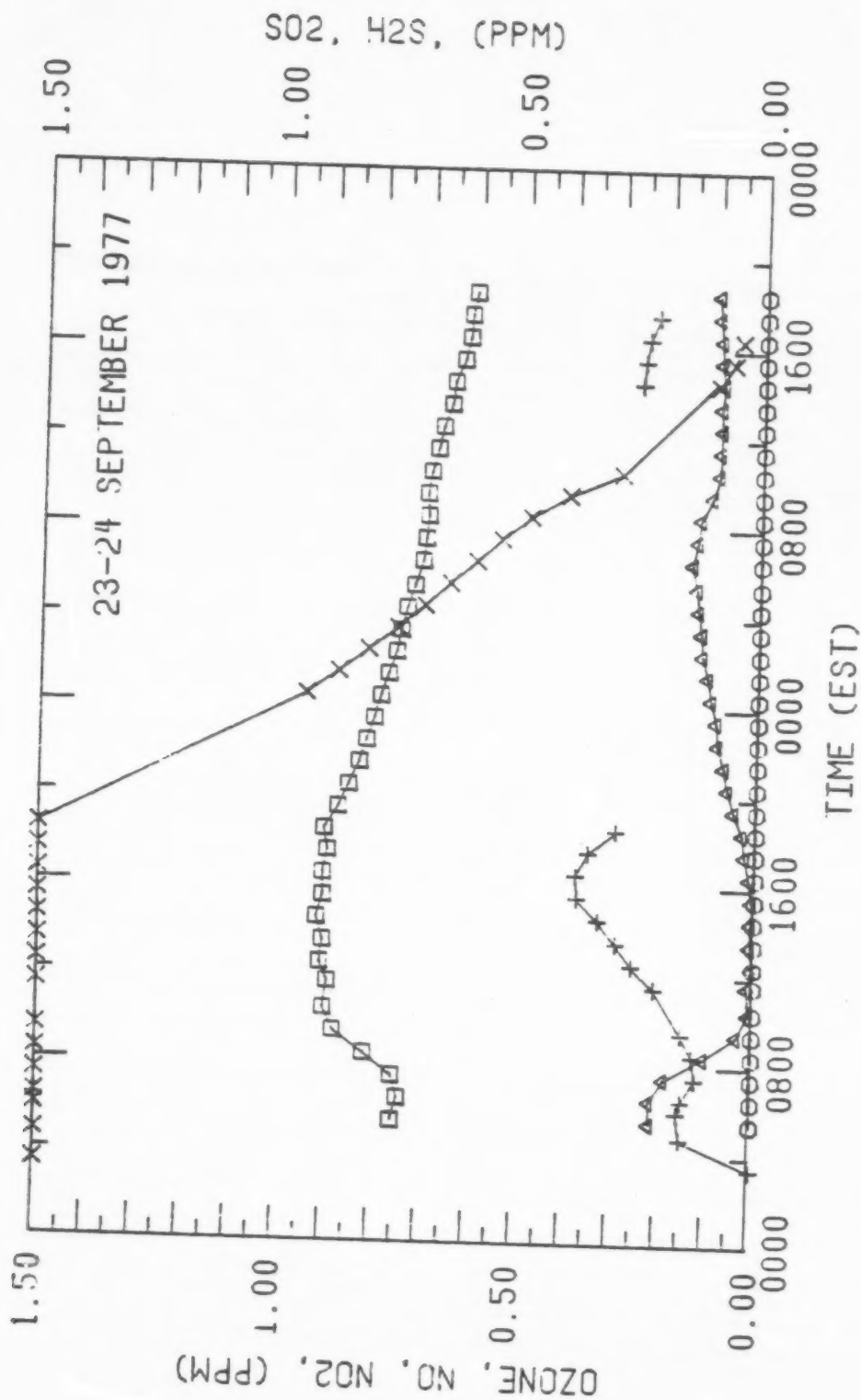


Figure 13. Concentration-time profiles of various reactants and products for the 23 and 24 September 1977 H₂S-NO_x experiment conducted in RTI Chamber No. 3. Target initial conditions: 2.0 ppm H₂S and 1.0 ppm NO_x. Symbol key: (x) O₃; (□) NO; (Δ) NO₂; (x) H₂S; and (+) SO₂.

TABLE 17. SUMMARY OF SELECTED RESULTS FROM SMOG CHAMBER EXPERIMENTS
CONDUCTED WITH H₂S AND NO_x

TEST COMPOUND ^{a/}	DATE ^{b/}	T _{max} ^{c/}	%SS ^{d/}	CU-SR ^{e/}	SUNRISE ^{f/}
Hydrogen Sulfide, H ₂ S	9-23-77 9-24-77	26.7 27.8	51 36	421 385	6.00
SMOG CHAMBER NUMBER		3	4	1	2
FIRST DAY PARAMETERS					
Target Initial HC/NO _x (ppmV/ppm)		2	4	10	20
Time of NO-NO ₂ Crossover, (hrs EST)		NA	NA	NA	NA
[NO ₂] _{max} , ppm		0.213	0.104	0.041	0.022
Time of [NO ₂] _{max} , (hrs EST)		6.47	6.63	5.13	5.30
[O ₃] _{max} , ppm		0.002	0.002	0.001	0.001
Time of [O ₃] _{max} , (hrs EST)		14.47	14.63	15.13	14.30
[PAN] _{max} , ppm		ND	ND	ND	ND
Time of [PAN] _{max} , (hrs EST)		NA	NA	NA	NA
[MN] ppm ^{g/}		ND	ND	ND	ND
[EN] ppm		ND	ND	ND	ND
[NO _x] _{initial} ^{h/}		0.954	0.489	0.202	0.103
[NO _x] @ 1700 EST		0.918	0.493	0.229	0.138
[NO _x] @ 1700 EST ^{i/}		0.962	1.008	1.134	1.340
[H ₂ S] @ 1700 EST ^{j/}		>1.5	>1.5	>1.5	>1.5
Time of [H ₂ S] _{k, P}		>1 day	>1 day	>1 day	>1 day
[SO ₂] _{max} , ppm		0.376	0.262	0.169	0.191
Time of [SO ₂] _{max} , (hrs EST)		16.47	15.63	15.13	16.30
[TPS] _{max} , µg/m ³		5.1	2.9	3.8	4.6
(ppmS)		0.004	0.002	0.003	0.004
Time of [TPS] _{max} , (hrs EST)		5.47	4.63	4.13	4.30
R ^{l/}		0.01	0	0	0
[CN] _{max} , cm ⁻³		110,000	105,000	125,000	130,000
Time of [CN] _{max} , (hrs EST)		17.47	14.63	17.13	14.30
Night-time O ₃ Half-Life (hrs) ^{m/}		NA	NA	NA	NA

NOTES: Abbreviations: ND = no data are available; NA = not applicable;
0 = not detected; tr = detected, but not quantified; X = concentration decreased, no maximum observed.

The appendix should be consulted for additional data that are not summarized in this table.

(continued)

TABLE 17. (continued)

SMOG CHAMBER NUMBER	3	4	1	2
SECOND DAY PARAMETERS				
$[O_3]_{\max}$, ppm	0	0	0	0.002
ΔO_3 , ppm ^{a/}	NA	NA	NA	0.002
$[SO_2]_{\max}$, ppm	0.257	0.200	0.198	0.194
ΔSO_2 , ppm ^{a, g/}	NA	NA	NA	NA
$[TPS]_{\max}$, $\mu g/m^3$	14.8	10.5	5.9	11.7
(ppmS)	0.011	0.008	0.005	0.009
$[CN]_{\max}$, cm^{-3}	21,000	32,000	37,000	47,000

- a/ Target initial concentration 2.0 ppm (V/V), or 2.0 ppmS.
- b/ Dates of first and second days of the experiment.
- c/ Daily maximum temperature in °C.²⁹
- d/ Duration of direct solar radiation reported as percent of possible minutes of sunshine.²⁹
- e/ Cumulative daily solar radiation expressed in Langley (cal cm⁻²); note that the second-day value is the cumulative solar radiation on that day until the experiment was terminated--usually 1700 EST.
- f/ Time of sunrise in hours (EST); since the times of sunrise are approximately the same for both days, the time is given for the first day only.
- g/ Daily median concentrations of species tentatively identified to be methyl and ethyl nitrate; they are not listed in the appendix.
- h/ The initial $[NO_x]$ is taken to be the concentration that existed at approximately the time of sunrise; the table entry has NOT been corrected for possible interferences.
- i/ Fraction of initial NO_x remaining at the 1700 EST hour calculated from NO_x concentrations as determined by the chemiluminescent NO_x analyzer.
- j/ Concentration of accountable test compound at the 1700 EST hour.
- k/ Estimate of the time at which approximately one-half of the test compound was consumed.
- l/ Ratio of product sulfur as particulate to the total accountable reacted sulfur at the time of $[SO_2]_{\max}$: $([TPS]/([TPS]+[SO_2]))$.
- m/ Estimate of ozone half-life based on data collected during the 2000 EST hour of the first day and the 0400 EST hour of the second day: $t_{1/2} \approx 5.545/\ln ([O_3]_{2000}/[O_3]_{0400})$.
- n/ This half-life may be suspect, since ozone concentrations smaller than 0.1 ppm were involved in its determination.
- o/ Net concentration on the second day is the difference between the second-day maximum concentration and the preceding minimum concentration: $\Delta O_3 = [O_3]_{\max} - [O_3]_{\min}$ and $\Delta SO_2 = [SO_2]_{\max} - [SO_2]_{\min}$.
- p/ The available data suggest that the time to one-half consumption of H_2S in these experiments exceeded 1 day.
- q/ Too few SO_2 data are available to permit the determination of ΔSO_2 for these experiments.

such as propene. Hydrogen sulfide did not act to promote the oxidation of NO to NO₂. In these experiments the reverse occurred--NO₂ was reduced to NO at such a rate that the conversion was essentially complete by 1000 EST. Thus, the maximum NO₂ concentrations listed in Table 17 are the initial values.

It is likely that the reduction of NO₂ to NO in the presence of H₂S involves a photochemical process, since the concentration of NO₂ decayed sharply during the first day but increased after sunset. The dark-phase increase in the NO₂ concentration presumably resulted from the thermal oxidation of NO. On the second day shortly after sunrise the NO₂ concentration decreased but then increased as if the remaining H₂S was no longer at a sufficient concentration to influence its behavior. This behavior was not as pronounced in chamber No. 3 as it was in the other chambers where the experiments were conducted at lower initial NO_x concentrations.

Since NO was not oxidized to NO₂, essentially no ozone accumulated on either day of the two-day experiments. In contrast, sulfur dioxide was generated during each experiment on both days. With the exception of Chamber No. 1 on the first day, the maximum concentrations of SO₂ increased with increasing initial NO_x (and NO₂) on both days. On the first day, maximum SO₂ concentrations occurred during the 1500 and 1600 EST hours. They also occurred late in the day on the second day.

A nitrogen mass balance was estimated for each experiment based on chemiluminescent NO_x concentrations determined initially and again during the 1700 EST hour of the first day. The fraction of initial NO_x that could be accounted for increased as the initial NO_x concentration was reduced. For the four experiments the fraction of the original NO_x that could be accounted for on the first day ranged from 0.96 at the highest initial NO_x concentration to 1.34 at the lowest. As noted in an earlier section, many of the tested sulfur compounds interfered with the chemiluminescent determination of nitrogen oxides. Since the target initial [H₂S] was identical for each chamber and the percentage of accountable NO_x increased with decreasing initial [NO_x], the apparent increase in [NO_x] may have resulted from interference by H₂S or by an unknown reaction product. This point deserves additional investigation.

For the most part, the initial concentrations of H_2S exceeded the linear range of the instrument. However, by the end of the first day sufficient H_2S had been consumed such that the concentration had dropped from the target initial value of 2.0 ppm to within the measurable range, less than 1.5 ppm. During the night the concentration of H_2S decreased in all four chambers and continued to drop after a small discontinuity that occurred shortly after sunrise on the second day. Although SO_2 data were not available, the TPS concentration data did not reflect a corresponding increase. Subsequent experiments conducted in Teflon bags also suggest that H_2S in the presence of NO_2 and sunlight decays with a concurrent conversion of NO_2 to NO . Additional dark-phase experiments, however, indicate that in the absence of irradiation mixtures of H_2S and NO_2 , and H_2S and NO are relatively stable. The nighttime decrease of $[\text{H}_2\text{S}]$ may be the result of interaction with products of the photochemical reactions that occurred during the previous day or with interactions with the chamber walls.

Copious quantities of condensation nuclei were generated in these experiments on the first day. They were not appreciably different for the four experiments, ranging from 105,000 to 130,000 cm^{-3} . Although the largest $[\text{CN}]_{\text{max}}$ occurred at the target HC/NO_x ratio of 20, first-day $[\text{CN}]_{\text{max}}$ displayed no apparent trends with initial HC/NO_x ratio. Moderate quantities of CN were produced on the second day. Maximum concentrations ranged from 21,000 to 47,000 cm^{-3} . The largest second-day maximum CN concentration also occurred at the target HC/NO_x ratio of 20 and maximum CN concentrations increased with increasing HC/NO_x ratios.

In spite of the formation of both SO_2 and CN, the concentrations of total particulate sulfur were low. Maximum concentrations ranged from 2.9 to 5.1 $\mu\text{g}/\text{m}^3$ which correspond to the equivalent of 2 to 4 ppb of sulfur. Since the TPS concentrations were low for each experiment, the ratios of product sulfur as particulate to the total accountable reacted sulfur ($[\text{TPS}]$ plus $[\text{SO}_2]$) were also low. In three cases the ratio was zero; in the fourth it was 0.01. Second-day TPS maxima were also low, although they exceeded first-day concentrations by a factor of approximately 2.

Carbonyl Sulfide

Mixtures of carbonyl sulfide and NO_x were irradiated on 18 and 19 September 1977. On 18 September the cumulative daily solar radiation was

463 cal cm⁻² with 77 percent of the possible minutes of direct sunshine and a maximum temperature of 30.6° C. Selected results from the COS-NO_x experiments are summarized in Table 18. Concentration-time profiles of various reactants and products for the experiment conducted in Chamber No. 3 are presented in Figure 14.

The photochemical behavior of irradiated mixtures of NO_x and COS was different from that of irradiated mixtures of NO_x and hydrocarbons. In most respects, the results from irradiating COS and NO_x were no different than those expected from irradiating NO_x in pure air. Carbonyl sulfide did not act to promote the oxidation of NO to NO₂, and NO-NO₂ crossover occurred in only one chamber, No. 2. In that case crossover occurred late in the day, at approximately 1640 EST, in the experiment with the lowest initial NO_x concentration.

Organic chamber contaminants can act to mediate the photooxidation of NO to NO₂. When the ratio of organics to nitrogen oxides is low and the NO_x exists primarily as NO, the apparent conversion of NO to NO₂ is slow and the system is said to be "NO inhibited." As the initial concentration of NO_x is reduced, the ratio of organics to NO_x is increased, the apparent conversion of NO to NO₂ becomes more rapid, and the system becomes less "NO inhibited." It is likely that the conversion of NO to NO₂ that occurred in Chamber No. 2 was mediated by chamber contaminants and not by the presence of COS.

On the first day ozone accumulated in only two of the four experiments, and the maximum concentrations were low in these two cases. Maximum concentrations were dependent on the initial HC/NO_x ratio (i.e., the initial NO_x concentration). Ozone maxima ranged from 0.000 to 0.011 ppm, and the nonzero maxima occurred during the 1300 EST hour. Maximum concentrations increased with increasing HC/NO_x ratio (i.e., decreasing NO_x concentration). For the four experiments the largest first-day maximum ozone concentration was 0.011 ppm and was achieved at the target initial HC/NO_x ratio of 20.

PAN, MN, and EN concentration data were not available for these experiments. Their formation, however, is unlikely in view of the chemical structure of COS.

A nitrogen balance was estimated for each experiment based on chemiluminescent NO_x concentrations determined initially and again during the 1700 EST hour of the first day. The nitrogen balance was good for all the COS

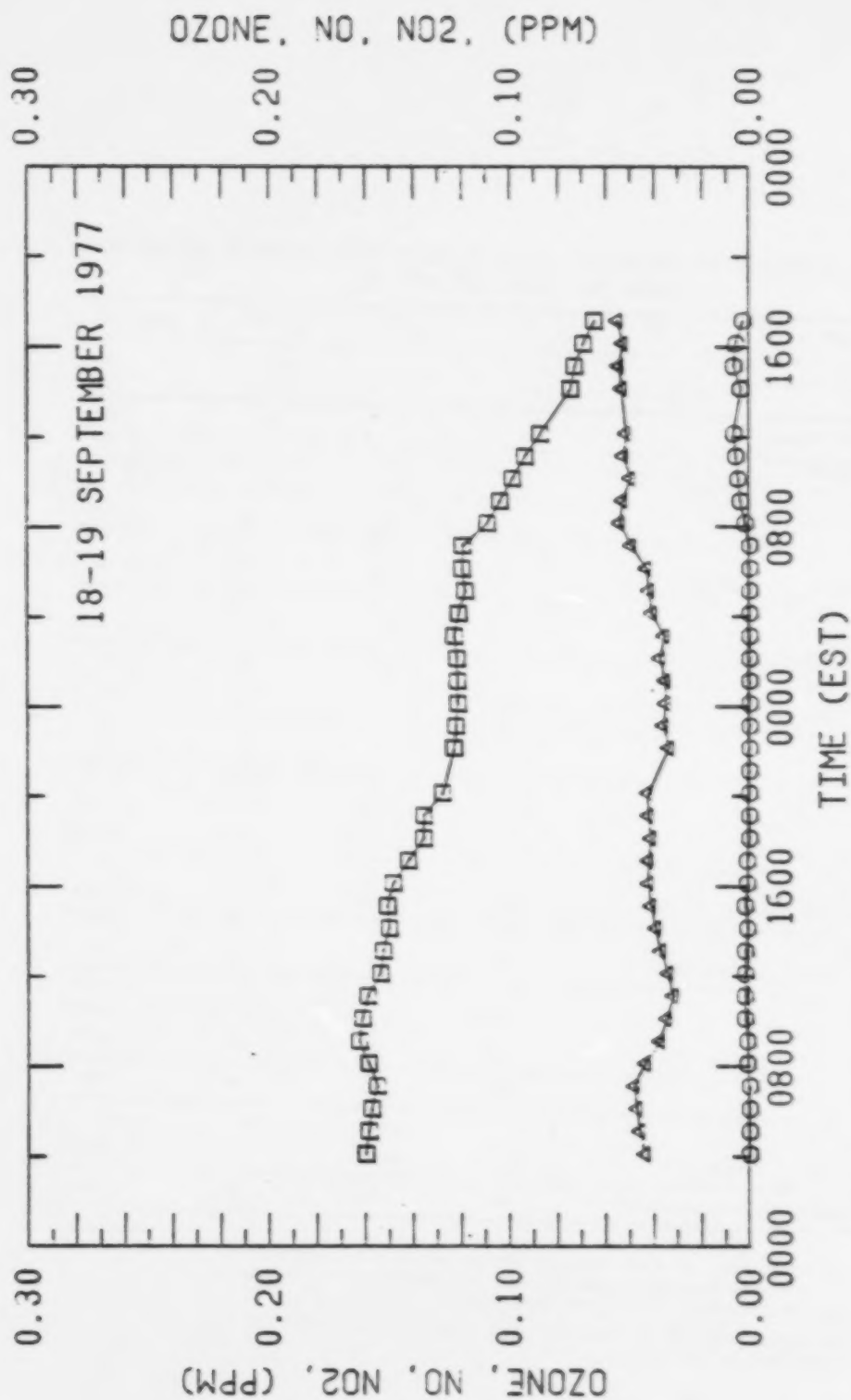


Figure 14. Concentration-time profiles of various reactants and products for the 18 and 19 September 1977 COS-NO_x experiment conducted in RTI Chamber No. 1. Target initial conditions: 2.0 ppm COS and 0.2 ppm NO_x. Symbol key: (o) O₃; (□) NO; and (Δ) NO₂.

TABLE 18. SUMMARY OF SELECTED RESULTS FROM SMOG CHAMBER EXPERIMENTS
CONDUCTED WITH COS AND NO_x

TEST COMPOUND ^{a/}	DATE ^{b/}	T _{max} ^{c/}	%SS ^{d/}	CU-SR ^{e/}	SUNRISE ^{f/}
Carbonyl Sulfide	9-18-77	30.6	77	463	5.95
COS	9-19-77	30.6	74	408	
SMOG CHAMBER NUMBER		3	4	1	2
FIRST DAY PARAMETERS					
Target Initial HC/NO _x (ppmC/ppm)		2	4	10	20
Time of NO-NO ₂ Crossover, (hrs EST)		NA	NA	NA	16.68
[NO ₂] _{max} , ppm		0.439	0.124	0.048	0.049
Time of [NO ₂] _{max} , (hrs EST)		5.47	7.63	7.13	20.30
[O ₃] _{max} , ppm		0	0	0.002	0.011
Time of [O ₃] _{max} , (hrs EST)		NA	NA	13.13	13.30
[PAN] _{max} , ppm		ND	ND	ND	ND
Time of [PAN] _{max} , (hrs EST)		NA	NA	NA	NA
[NM] ppm ^{g/}		ND	ND	ND	ND
[EN] ppm		ND	ND	ND	ND
[NO] _x initial ^{h/}		1.176	0.491	0.204	0.100
[NO] _x @ 1700 EST		1.071	0.431	0.184	0.089
ENO _x @ 1700 EST ^{i/}		0.911	0.878	0.902	0.890
[COS] @ 1700 EST ^{j/}		>1.5	>1.5	>1.5	>1.5
Time of [COS] _{max} , ^{k/}		>2 days	>2 days	>2 days	>2 days
[SO ₂] _{max} , ppm		ND	ND	ND	ND
Time of [SO ₂] _{max} , (hrs EST)		NA	NA	NA	NA
[TPS] _{max} , µg/m ³		3.4	0	0	6.3
(ppmS)		0.003	0	0	0.005
Time of [TPS] _{max} , (hrs EST)		5.47	NA	NA	6.30
R ^{l/}		ND	ND	ND	ND
[CN] _{max} , cm ⁻³		8,100	220	8,100	5,600
Time of [CN] _{max} , (hrs EST)		9.47	10.63	9.13	9.30
Night-time O ₃ Half-Life (hrs) ^{m/}		NA	NA	NA	NA

(continued)

NOTES: Abbreviations: ND = no data are available; NA = not applicable;
0 = not detected; tr = detected, but not quantified; X = concen-
tration decreased, no maximum observed.

The appendix should be consulted for additional data that are not
summarized in this table.

TABLE 18. (continued)

SMOG CHAMBER NUMBER	3	4	1	2
SECOND DAY PARAMETERS				
$[O_3]_{\max}$, ppm	0	0.001	0.007	0.028
ΔO_3 , ppm ^{a/}	NA	0.001	0.007	0.028
$[SO_2]_{\max}$, ppm	ND	ND	ND	ND
ΔSO_2 , ppm ^{a/}	NA	NA	NA	NA
$[TPS]_{\max}$, $\mu g/m^3$	0	0	0	0
(ppmS)	0	0	0	0
$[CN]_{\max}$, cm^{-3}	0	0	840	0

^{a/} Target initial concentration 2.0 ppmC, 2.0 ppm (V/V), or 2.0 ppmS.

^{b/} Dates of first and second days of the experiment.

^{c/} Daily maximum temperature in °C.²⁹

^{d/} Duration of direct solar radiation reported as percent of possible minutes of sunshine.²⁹

^{e/} Cumulative daily solar radiation expressed in Langley's ($cal\ cm^{-2}$); note that the second-day value is the cumulative solar radiation on that day until the experiment was terminated--usually 1700 EST.

^{f/} Time of sunrise in hours (EST); since the times of sunrise are approximately the same for both days, the time is given for the first day only.

^{g/} Daily median concentrations of species tentatively identified to be methyl and ethyl nitrate; they are not listed in the appendix.

^{h/} The initial $[NO_x]$ is taken to be the concentration that existed at approximately the time of sunrise; the table entry has NOT been corrected for possible interferences.

^{i/} Fraction of initial NO_x remaining at the 1700 EST hour calculated from NO_x concentrations as determined by the chemiluminescent NO_x analyzer.

^{j/} Concentration of accountable test compound at the 1700 EST hour.

^{k/} Estimate of the time at which approximately one-half of the test compound was consumed.

^{l/} Ratio of product sulfur as particulate to the total accountable reacted sulfur at the time of $[SO_2]_{\max}$: $([TPS]/([TPS]+[SO_2]))$.

^{m/} Estimate of ozone half-life based on data collected during the 2000 EST hour of the first day and the 0400 EST hour of the second day: $t_{1/2} = 5.545/\ln ([O_3]_{2000}/[O_3]_{0400})$.

^{n/} This half-life may be suspect, since ozone concentrations smaller than 0.1 ppm were involved in its determination.

^{o/} Net concentration on the second day is the difference between the second-day maximum concentration and the preceding minimum concentration: $\Delta O_3 = [O_3]_{\max} - [O_3]_{\min}$ and $\Delta SO_2 = [SO_2]_{\max} - [SO_2]_{\min}$.

^{p/} COS was stable in these experiments; the available data suggest that the time to one-half consumption of COS in these experiments exceeded 2 days.

experiments. For the four experiments the fraction of initial NO_x that could be accounted for ranged from 0.88 to 0.91. This fraction showed no apparent trends with initial HC/NO_x ratio. The unaccountable product nitrogen may be nitric acid or other undetermined nitrogen-containing species. The fate of NO_x in photochemically reacting systems is largely unknown.

Irradiation of COS in the presence of NO_x resulted in the production of small quantities of condensation nuclei. Maximum concentrations ranged from 220 to 8100 cm^{-3} and occurred early on the first day, displaying no apparent trends with initial HC/NO_x ratio.

Maximum total particulate sulfur concentrations were low and displayed no apparent trends with initial HC/NO_x ratio. Particulate sulfur was detected in only two of the four experiments. Maximum TPS concentrations ranged from 0 to 6.3 $\mu\text{g}/\text{m}^3$, which correspond to the equivalent of 0 to 5 ppb of sulfur. In each chamber the most frequent TPS concentration was 0 $\mu\text{g}/\text{m}^3$.

Neither COS nor SO_2 concentration data were available for these experiments. This deficiency prevents an assessment of the extent of reaction for COS or whether SO_2 was a reaction product. The slow oxidation of NO, the formation of negligible quantities of O_3 , the low maximum CN concentrations, and the very low maximum TPS concentrations, however, suggest that COS is relatively unreactive in the presence of NO_x and sunlight.

Second day results also suggest that COS is unreactive. Aside from the experiment where NO- NO_2 crossover was achieved on the first day, NO- NO_2 crossover was not achieved in the three remaining experiments on either day. Ozone maxima on the second day increased with increasing initial HC/NO_x ratio as had occurred on the first day. Although second-day $[\text{O}_3]_{\text{max}}$ generally exceeded the first day levels, ozone accumulated in only three experiments and ranged from 0.000 to 0.028 ppm. The largest second-day $[\text{O}_3]_{\text{max}}$ was 0.028 ppm and was achieved in the experiment conducted at a target HC/NO_x ratio of 20. Condensation nuclei were detected in only one chamber, and particulate sulfur was not detected in any chamber on the second day.

Carbon Disulfide

Mixtures of carbon disulfide and NO_x were irradiated on 21 and 22 September 1977. On 21 September the cumulative daily solar radiation was

451 cal cm⁻² with 64 percent of the possible minutes of direct sunshine and a maximum temperature of 26.7° C. Selected results from the CS₂-NO_x experiments are summarized in Table 19. Concentration-time profiles of various reactants and products for the experiment conducted in Chamber No. 2 are presented in Figure 15.

Nitric oxide was oxidized to NO₂ in the presence of CS₂ and sunlight at a rate that was dependent on the initial HC/NO_x ratio. The duration of irradiation required to achieve NO-NO₂ crossover decreased with increasing HC/NO_x ratios (i.e., decreasing initial concentrations of NO_x). The most rapid conversion occurred at the target HC/NO_x ratio of 20 where crossover was achieved at 0703 EST, approximately one hour after sunrise. In contrast, at the target HC/NO_x ratio of 2, crossover was not achieved during the complete 2-day experimental period.

Ozone accumulated on the first day during three of the four experiments. Maximum concentrations were dependent on the initial HC/NO_x ratio (i.e., the initial NO_x concentration). Ozone was not observed in the one experiment where NO-NO₂ crossover had not been achieved. For the remaining three experiments ozone maxima ranged from 0.005 to 0.33 ppm and occurred during the 1500 and 1600 EST hours. Maximum ozone concentrations increased with increasing HC/NO_x ratios (i.e., decreasing NO_x concentrations). The largest [O₃]_{max}, 0.33 ppm was achieved at the target HC/NO_x ratio of 20, the condition that had resulted in the most rapid oxidation of NO.

PAN, MN, and EN concentration data were not available for these experiments. Their formation, however, is unlikely in view of the chemical structure of CS₂.

A nitrogen mass balance was estimated for each experiment based on chemiluminescent NO_x concentrations determined initially and again during the 1700 EST hour of the first day. For the four experiments the fraction of initial NO_x that could be accounted for ranged from 0.32 to 0.81. This fraction decreased with increasing HC/NO_x ratios (i.e., decreasing NO_x concentrations). Moreover, reduction of the accountable NO_x was associated with increased maximum ozone concentrations. The unaccountable product nitrogen may be nitric acid or other undetermined nitrogen-containing species.

TABLE 19. SUMMARY OF SELECTED RESULTS FROM SMOG CHAMBER EXPERIMENTS
CONDUCTED WITH CS₂ AND NO_x

TEST COMPOUND ^{a/}	DATE ^{b/}	T _{max} ^{c/}	%SS ^{d/}	CU-SR ^{e/}	SUNRISE ^{f/}
Carbon Disulfide	9-21-77	26.7	64	451	5.98
CS ₂	9-22-77	26.1	68	413	
SMOG CHAMBER NUMBER		3	4	1	2
FIRST DAY PARAMETERS					
Target Initial HC/NO _x (ppmC/ppm)		2	4	10	20
Time of NO-NO ₂ Crossover, (hrs EST)		NA	12.41	8.69	7.05
[NO ₂] _{max} , ppm		NA	0.206	0.118	0.074
Time of [NO ₂] _{max} , (hrs EST)		NA	16.63	11.13	8.30
[O ₃] _{max} , ppm		0	0.005	0.052	0.333
Time of [O ₃] _{max} , (hrs EST)		NA	15.63	15.13	16.30
[PAN] _{max} , ppm		ND	ND	ND	ND
Time of [PAN] _{max} , (hrs EST)		NA	NA	NA	NA
[MN] ppm ^{g/}		ND	ND	ND	ND
[EN] ppm		ND	ND	ND	ND
[NO] _x initial ^{h/}		0.977	0.486	0.204	0.102
[NO] _x @ 1700 EST		0.789	0.349	0.131	0.033
fNO _x @ 1700 EST ^{i/}		0.808	0.718	0.642	0.324
fCS ₂ EST ^{j/}		0.86	0.78	0.72	0.62
Time of [CS ₂] _{k, p/}		>1 day	>1 day	>1 day	>1 day
[COS] _{max} , ppm ^{q/}		0.271	0.439	0.551	0.763
Time of [COS] _{max} , (hrs EST)		22.47	18.63	18.13	17.30
[TPS] _{max} , µg/m ³		0	4.3	0.	11.4
(ppmS)		0	0.003	0	0.009
Time of [TPS] _{max} , (hrs EST)		NA	15.63	NA	15.30
R ^{l/}		ND	ND	ND	ND
[CN] _{max} , cm ⁻³		91,000	150,000	180,000	120,000
Time of [CN] _{max} , (hrs EST)		8.47	7.63	8.13	7.30
Night-time O ₃ Half-Life (hrs) ^{m/}		NA	NA	NA	16

(continued)

NOTES: Abbreviations: ND = no data are available; NA = not applicable;
0 = not detected; tr = detected, but not quantified; X = concen-
tration decreased, no maximum observed.

The appendix should be consulted for additional data that are not
summarized in this table.

TABLE 19. (continued)

SMOG CHAMBER NUMBER	3	4	1	2
SECOND DAY PARAMETERS				
$[O_3]_{\max}$, ppm	0	0.048	0.295	0.333
ΔO_3 , ppm ^{a/}	NA	0.048	0.295	0.191
$[SO_2]_{\max}$, ppm	0.132	0.168	0.163	0.139
ΔSO_2 , ppm ^{a/}	0.132	0.168	0.163	0.139
$[COS]_{\max}$, ppm	0.526	0.820	1.145	1.071
ΔCOS , ppm	0.294	0.413	0.631	0.389
$[TPS]_{\max}$, $\mu\text{g}/\text{m}^3$ (ppmS)	3.3	3.9	5.4	7.5
	0.003	0.003	0.004	0.006
$[CN]_{\max}$, cm^{-3}	83,000	100,000	61,000	27,000

a/ Target initial concentration 2.0 ppmC, 2.0 ppm (V/V), or 4.0 ppmS.

b/ Dates of first and second days of the experiment.

c/ Daily maximum temperature in °C.²⁹

d/ Duration of direct solar radiation reported as percent of possible minutes of sunshine.²⁹

e/ Cumulative daily solar radiation expressed in Langley (cal cm^{-2}); note that the second-day value is the cumulative solar radiation on that day until the experiment was terminated--usually 1700 EST.

f/ Time of sunrise in hours (EST); since the times of sunrise are approximately the same for both days, the time is given for the first day only.

g/ Daily median concentrations of species tentatively identified to be methyl and ethyl nitrate; they are not listed in the appendix.

h/ The initial $[NO]_x$ is taken to be the concentration that existed at approximately the time of sunrise^x; the table entry has NOT been corrected for possible interferences.

i/ Fraction of initial NO_x remaining at the 1700 EST hour calculated from NO_x concentrations as determined by^x the chemiluminescent NO_x analyzer.

j/ Estimated fraction of accountable test compound at the 1700 EST hour.

k/ Estimate of the time at which approximately one-half of the test compound was consumed.

l/ Ratio of product sulfur as particulate to the total accountable reacted sulfur at the time of $[SO_2]_{\max}$: $([TPS]/([TPS]+[SO_2]))$.

m/ Estimate of ozone half-life based on data collected during the 2000 EST hour of the first day and the 0400 EST hour of the second day: $t_{1/2} \approx 5.545/\ln([O_3]_{2000}/[O_3]_{0400})$.

n/ This half-life may be suspect, since ozone concentrations smaller than 0.1 ppm were involved in its determination.

o/ Net concentration on the second day is the difference between the second-day maximum concentration and the preceding minimum concentration: $\Delta O_3 = [O_3]_{\max} - [O_3]_{\min}$ and $\Delta SO_2 = [SO_2]_{\max} - [SO_2]_{\min}$.

p/ The available data suggest that the time to one-half consumption of CS_2 in these experiments exceeded one day.

q/ Note that SO_2 data were not available on the first day.

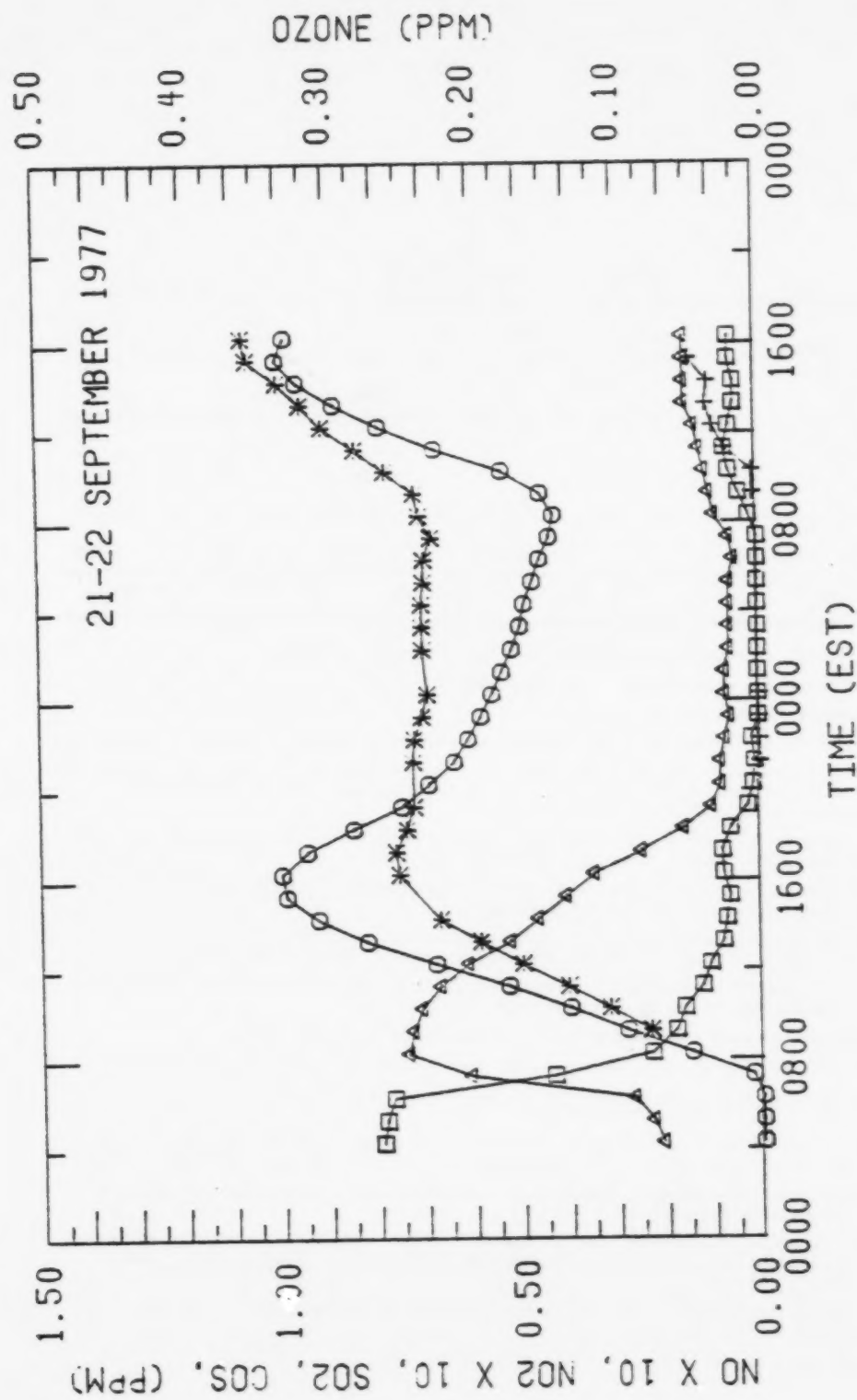


Figure 15. Concentration-time profiles of various reactants and products for the 21 and 22 September 1977 CS₂-NO_x experiment conducted in RTI Chamber No. 2. Target initial conditions: 2.0 ppmC CS₂ and 0.10 ppm NO_x. Symbol key: (o) O₃; (□) NO; (Δ) NO₂; (+) SO₂; and (*) COS.

It is difficult, however, to devise mechanisms that could account for the formation of organic nitrates or even nitric acid from the photooxidation of CS₂ in the presence of NO_x. The fate of NO_x in photochemically reacting systems is largely unknown.

During these experiments the concentrations of CS₂ exceeded the linear range of the instrument and were not determined. Product species, however, were quantified. Carbonyl sulfide, in addition to SO₂, was found in each of the four experiments as a product of the photooxidation of CS₂ in the presence of NO_x. Too few data were available to permit assessment of first-day maximum SO₂ concentrations. Maximum COS concentrations were dependent on the initial HC/NO_x ratio. Maximum first-day COS concentrations ranged from 0.27 to 0.76 ppm and generally occurred late in the day during the 1700 and 1800 EST hours. The apparent relationship between [COS]_{max} and initial HC/NO_x ratio was similar to that observed earlier for another reaction product, ozone. Maximum COS concentrations increased with increasing HC/NO_x ratio (i.e., decreasing initial NO_x concentration). For the four experiments the largest [COS]_{max} was 0.76 ppm and was achieved at the target initial HC/NO_x ratio of 20. Since the COS formation is an unexpected finding, additional work is needed to explore possible formation mechanisms.

Based on an assumed COS yield of unity for the photooxidation of CS₂ and on having achieved the target initial CS₂ concentration of 2 ppm (V/V), estimates were made of the fraction of initial CS₂ that remained unreacted at the times of the maximum COS concentrations. These results suggest that the disappearance rate of CS₂ was dependent on the initial HC/NO_x ratio. At the target HC/NO_x ratio of 20 the smallest fraction of the initially present CS₂ could be accounted for. The fraction of initial CS₂ that remained ranged from 0.62 to 0.86. The ordering of the accountable fraction of CS₂ is similar to that of NO_x, the other reactant. In both cases the accountable fractions decreased with increasing initial HC/NO_x ratio (i.e. with decreasing initial NO_x concentration).

Based on the previous assumption of unity COS yield, a similar yield for SO₂ might also be anticipated for the second sulfur atom in the CS₂ molecule. Sulfur dioxide concentration data were too few to provide conclu-

sive evidence. The available data, however, indicate that the concentration of SO_2 in each experiment was substantially smaller than that of COS. This suggests that either the SO_2 yield was not unity or that after its formation, the SO_2 was being rapidly removed by an undefined mechanism. The removal processes could include gas-phase reactions as well as deposition on the chamber walls.

Irradiation of CS_2 in the presence of NO_x yielded copious quantities of condensation nuclei. Maximum concentrations ranged from 91,000 to 180,000 cm^{-3} and generally occurred early (before 0900 EST) on the first day. Although the $[\text{CN}]_{\text{max}}$ displayed no apparent trends with initial HC/NO_x ratio, in the three experiments where $\text{NO}-\text{NO}_2$ crossover occurred, the maximum CN values exceeded 100,000 cm^{-3} .

In spite of the formation of both CN and SO_2 , only a small portion of the reacted CS_2 was detected as particulate sulfur. Maximum particulate sulfur concentrations ranged from 0 to 11.4 $\mu\text{g}/\text{m}^3$ and correspond to the equivalent of 0 to 9 ppb of sulfur. In the two experiments where particulate sulfur was detected, the maximum TPS concentrations occurred during the 1500 EST hour. The TPS data displayed no apparent trends with HC/NO_x ratio, although the largest $[\text{TPS}]_{\text{max}}$ was achieved in the same experiment where the largest $[\text{O}_3]_{\text{max}}$ and $[\text{COS}]_{\text{max}}$ values occurred.

Second-day $[\text{TPS}]_{\text{max}}$ were also small, ranging from 3.3 to 7.5 $\mu\text{g}/\text{m}^3$ (3 to 6 ppbS). In contrast, significant quantities of CN, SO_2 , COS, and O_3 were generated on the second day. Maximum $[\text{CN}]_{\text{max}}$ on the second day were generally high, ranging from 27,000 to 100,000 cm^{-3} , but did not exceed the first day values. Second-day $[\text{SO}_2]_{\text{max}}$ ranged from 0.13 to 0.17 ppm. The highest second-day $[\text{CN}]_{\text{max}}$ and $[\text{SO}_2]_{\text{max}}$ were achieved at the target HC/NO_x ratio of 4, and both decreased as the initial target ratio was moved away from 4. In every case the second-day maximum COS concentration exceeded the corresponding first-day maximum, and in two cases the second-day net COS concentration exceeded the first-day maximum. Net COS concentrations ranged from 0.29 to 0.63 ppm. At target initial HC/NO_x ratios of 4, 10, and 20, second-day $[\text{O}_3]_{\text{max}}$ and net O_3 equaled or exceeded the first-day maxima. Net O_3 concentrations ranged from 0 to 0.30 ppm. The ordering of the net COS

and net O_3 concentrations were similar with respect to HC/NO_x ratio. The highest net ozone and net carbonyl sulfide concentrations were produced at the target HC/NO_x ratio of 10, and both decreased as the initial target ratio was moved away from 10.

Methanethiol

Mixtures of methanethiol and NO_x were irradiated in Chamber Nos. 1 and 3 on 26 and 27 August and in all four chambers on 2 and 3 September 1977. On 26 August the cumulative daily solar radiation was 417 cal cm^{-2} with 55 percent of the possible minutes of direct sunshine and a maximum temperature of 289° C . On 2 September the cumulative daily solar radiation was 468 cal cm^{-2} with 92 percent of the possible minutes of direct sunshine and a maximum temperature of 32.2° C . Selected results from the CH_3SH-NO_x experiments are summarized in Tables 20 and 21. In general, only the September experiments are considered in the current discussion. Concentration-time profiles of various reactants and products for the 2 September experiment conducted in Chamber No. 4 are presented in Figure 16.

The photochemical behavior of irradiated mixtures of NO_x and CH_3SH was similar in many respects to that of irradiated mixtures of NO_x and a hydrocarbon such as propene. In each of these experiments conversion of NO to NO_2 was rapid. Approximately 2 hours of irradiation were required to achieve $NO-NO_2$ crossover with the maximum NO_2 concentrations occurring during the 0800 EST hour. Among the four experiments conversion was the slowest at the target HC/NO_x ratio of 4, and conversion became more rapid as the target HC/NO_x ratio was moved away from 4. In contrast to the propene NO_x system, however, the time to crossover was not strongly dependent on HC/NO_x ratio.

Ozone accumulated during each experiment. Maximum concentrations and the times required to achieve them were dependent on the initial HC/NO_x ratio (i.e., initial NO_x concentration). Ozone maxima ranged from 0.30 to 0.59 ppm and generally occurred between the 1000 and 1300 EST hours. For the four experiments an $[O_3]_{\text{max}}$ occurred first in Chamber No. 4 at the target HC/NO_x ratio of 4. The largest $[O_3]_{\text{max}}$, 0.59 ppm, also occurred at the target HC/NO_x ratio of 4. As the target HC/NO_x ratio was moved away from 4, maximum ozone concentrations decreased. These reductions in maximum ozone concentrations are also associated with small decreases in the times to $NO-NO_2$ crossover.

TABLE 20. SUMMARY OF SELECTED RESULTS FROM SMOG CHAMBER EXPERIMENTS
CONDUCTED WITH CH₃SH AND NO_x

TEST COMPOUND ^{a/}	DATE ^{b/}	T _{max} ^{c/}	SS ^{d/}	CU-SR ^{e/}	SUNRISE ^{f/}
Methanethiol, CH ₃ SH	8-26-77 8-27-77	28.9 30.0	55 49	417 404	5.65
SMOG CHAMBER NUMBER			1	3	
FIRST DAY PARAMETERS					
Target Initial HC/NO _x (ppmC/ppm)			10	10	
Time of NO-NO ₂ Crossover, (hrs EST)			8.25	7.79	
[NO ₂] _{max} , ppm			0.464	0.442	
Time of [NO ₂] _{max} , (hrs EST)			9.13	8.47	
[O ₃] _{max} , ppm			0.641	0.702	
Time of [O ₃] _{max} , (hrs EST)			11.13	10.47	
[PAN] _{max} , ppm			0	0	
Time of [PAN] _{max} , (hrs EST)			NA	NA	
[MN] ppm ^{g/}			0.033	0.028	
[EN] ppm			ND	ND	
[NO _x] initial ^{h/}			0.655	0.660	
[NO _x] @ 1700 EST			0.036	0.035	
ENO _x @ 1700 EST ^{i/}			0.055	0.053	
[CH ₃ SH] @ 1700 EST ^{j/}			ND	ND	
Time of [CH ₃ SH] _k , (hrs EST) ^{k/}			ND	ND	
[SO ₂] _{max} , ppm			ND	ND	
Time of [SO ₂] _{max} , (hrs EST)			NA	NA	
[TPS] _{max} , µg/m ³			372.4	232.8	
(ppmS)			0.285	0.178	
Time of [TPS] _{max} , (hrs EST)			11.13	11.47	
R ^{l/}			ND	ND	
[CN] _{max} , cm ⁻³			14,000	20,000	
Time of [CN] _{max} , (hrs EST)			12.13	20.47	
Night-time O ₃ Half-Life (hrs) ^{m/}			8	12	

(continued)

NOTES: Abbreviations: ND = no data are available; NA = not applicable;
0 = not detected; tr = detected, but not quantified; X = concentra-
tion decreased, no maximum observed.

The appendix should be consulted for additional data that are not
summarized in this table.

TABLE 20. (continued)

SMOG CHAMBER NUMBER	1	3
SECOND DAY PARAMETERS		
$[O_3]_{\max}$, ppm	0.295	0.332
ΔO_3 , ppm ^{a/}	0.210	0.166
$[SO_2]_{\max}$, ppm	ND	ND
ΔSO_2 , ppm ^{a/}	NA	NA
$[TPS]_{\max}$, $\mu\text{g}/\text{m}^3\text{R/}$ (ppmS) ^{b/}	6.8 0.005	4.4 0.003
$[CN]_{\max}$, cm^{-3}	17,000	26,000

^{a/} Target initial concentration 5.0 ppmC, 5.0 ppm (V/V), or 5.0 ppmS.

^{b/} Dates of first and second days of the experiment.

^{c/} Daily maximum temperature in °C.²⁹

^{d/} Duration of direct solar radiation reported as percent of possible minutes of sunshine.²⁹

^{e/} Cumulative daily solar radiation expressed in Langleys (cal cm^{-2}); note that the second-day value is the cumulative solar radiation on that day until the experiment was terminated--usually 1700 EST.

^{f/} Time of sunrise in hours (EST); since the times of sunrise are approximately the same for both days, the time is given for the first day only.

^{g/} Daily median concentrations of species tentatively identified to be methyl and ethyl nitrate; they are not listed in the appendix.

^{h/} The initial $[NO_x]$ is taken to be the concentration that existed at approximately the time of sunrise; the table entry has NOT been corrected for possible interferences.

^{i/} Fraction of initial NO_x remaining at the 1700 EST hour calculated from NO_x concentrations as determined by the chemiluminescent NO_x analyzer.

^{j/} Concentration of accountable test compound at the 1700 EST hour.

^{k/} Estimate of the time at which approximately one-half of the test compound was consumed.

^{l/} Ratio of product sulfur as particulate to the total accountable reacted sulfur at the time of $[SO_2]_{\max}$: $(([TPS])/([TPS]+[SO_2]))$.

^{m/} Estimate of ozone half-life based on data collected during the 2000 EST hour of the first day and the 0400 EST hour of the second day: $t_{1/2} \approx 5.545/\ln ([O_3]_{2000}/[O_3]_{0400})$.

^{n/} This half-life may be suspect, since ozone concentrations smaller than 0.1 ppm were involved in its determination.

^{o/} Net concentration on the second day is the difference between the second-day maximum concentration and the preceding minimum concentration: $\Delta O_3 = [O_3]_{\max} - [O_3]_{\min}$ and $\Delta SO_2 = [SO_2]_{\max} - [SO_2]_{\min}$.

^{p/} Since second-day [TPS] were determined only once for each chamber, these data do not truly represent maximum values.

TABLE 21. SUMMARY OF SELECTED RESULTS FROM SMOG CHAMBER EXPERIMENTS
CONDUCTED WITH CH₃SH AND NO_x

TEST COMPOUND ^{a/}	DATE ^{b/}	T _{max} ^{c/}	%SS ^{d/}	CU-SR ^{e/}	SUNRISE ^{f/}
Methanethiol	9-2-77	32.2	92	468	5.77
CH ₃ SH	9-3-77	33.9	80	529	
SMOG CHAMBER NUMBER		3	4	1	2
FIRST DAY PARAMETERS					
Target Initial HC/NO _x (ppmC/ppm)		2	4	10	20
Time of NO-NO ₂ Crossover, (hrs EST)		7.65	7.97	7.76	7.67
[NO ₂] _{max} , ppm		0.656	0.393	0.124	0.073
Time of [NO ₂] _{max} , (hrs EST)		8.47	8.63	8.13	8.30
[O ₃] _{max} , ppm		0.483	0.591	0.391	0.297
Time of [O ₃] _{max} , (hrs EST)		13.47	10.63	11.13	13.30
[PAN] _{max} , ppm		0	0	0	0
Time of [PAN] _{max} , (hrs EST)		NA	NA	NA	NA
[MN] ppm ^{g/}		0.020	0.013	0.005	0.002
[EN] ppm		ND	ND	ND	ND
[NO _x] _{initial} ^{h/}		0.983	0.553	0.204	0.100
[NO _x] @ 1700 EST		0.033	0.025	0.017	0.015
fNO _x @ 1700 EST ^{i/}		0.034	0.045	0.083	0.150
[CH ₃ SH] @ 1700 EST ^{j/}		0	0	0	0.17
Time of [CH ₃ SH] _{1/2} (hrs EST) ^{k/}		7.67	8.11	8.51	9.23
[SO ₂] _{max} , ppm		1.202	1.149	1.500	1.390
Time of [SO ₂] _{max} , (hrs EST)		10.47	9.63	11.13	11.30
[TPS] _{max} , µg/m ³		498.9	759.7	231.4	180.2
(ppmS)		0.382	0.581	0.177	0.138
Time of [TPS] _{max} , (hrs EST)		10.47	9.63	8.13	9.30
R ^{l/}		0.241	0.336	0.072	0.057
[CN] _{max} , cm ⁻³		34,000	31,000	23,000	34,000
Time of [CN] _{max} , (hrs EST)		8.47	8.63	8.13	8.30
Night-time O ₃ Half-Life (hrs) ^{m/}		11	9	5 ^{n/}	3 ^{n/}

(continued)

NOTES: Abbreviations: ND = no data are available; NA = not applicable;
0 = not detected; tr = detected, but not quantified; X = concentration decreased, no maximum observed.

The appendix should be consulted for additional data that are not summarized in this table.

TABLE 21. (continued)

SMOG CHAMBER NUMBER	3	4	1	2
SECOND DAY PARAMETERS				
$[O_3]_{max}$, ppm	0.358	0.355	0.291	0.388
ΔO_3 , ppm ^{a/}	0.187	0.189	0.247	0.375
$[SO_2]_{max}$, ppm	ND	ND	ND	0.398
ΔSO_2 , ppm ^{a/}	NA	NA	NA	NA
$[TPS]_{max}$, $\mu g/m^3$ (ppmS)	3.6 0.003	2.8 0.002	5.4 0.004	16.7 0.013
$[CN]_{max}$, cm^{-3}	92,000	140,000	80,000	52,000

^{a/} Target initial concentration 2.0 ppmC, 2.0 ppm (V/V), or 2.0 ppmS.

^{b/} Dates of first and second days of the experiment.

^{c/} Daily maximum temperature in °C.²⁹

^{d/} Duration of direct solar radiation reported as percent of possible minutes of sunshine.²⁹

^{e/} Cumulative daily solar radiation expressed in Langleys ($cal\ cm^{-2}$); note that the second-day value is the cumulative solar radiation on that day until the experiment was terminated--usually 1700 EST.

^{f/} Time of sunrise in hours (EST); since the times of sunrise are approximately the same for both days, the time is given for the first day only.

^{g/} Daily median concentrations of species tentatively identified to be methyl and ethyl nitrate; they are not listed in the appendix.

^{h/} The initial $[NO_x]$ is taken to be the concentration that existed at approximately the time of sunrise; the table entry has NOT been corrected for possible interferences.

^{i/} Fraction of initial NO_x remaining at the 1700 EST hour calculated from NO_x concentrations as determined by^x the chemiluminescent NO_x analyzer.

^{j/} Concentration of accountable test compound at the 1700 EST hour.

^{k/} Estimate of the time at which approximately one-half of the test compound was consumed.

^{l/} Ratio of product sulfur as particulate to the total accountable reacted sulfur at the time of $[SO_2]_{max}$: $([TPS]/([TPS]+[SO_2]))$.

^{m/} Estimate of ozone half-life based on data collected during the 2000 EST hour of the first day and the 0400 EST hour of the second day: $t_{1/2} = 3.345/\ln ([O_3]_{2000}/[O_3]_{0400})$.

^{n/} This half-life may be suspect, since ozone concentrations smaller than 0.1 ppm were involved in its determination.

^{o/} Net concentration on the second day is the difference between the second-day maximum concentration and the preceding minimum concentration: $\Delta O_3 = [O_3]_{max} - [O_3]_{min}$ and $\Delta SO_2 = [SO_2]_{max} - [SO_2]_{min}$.

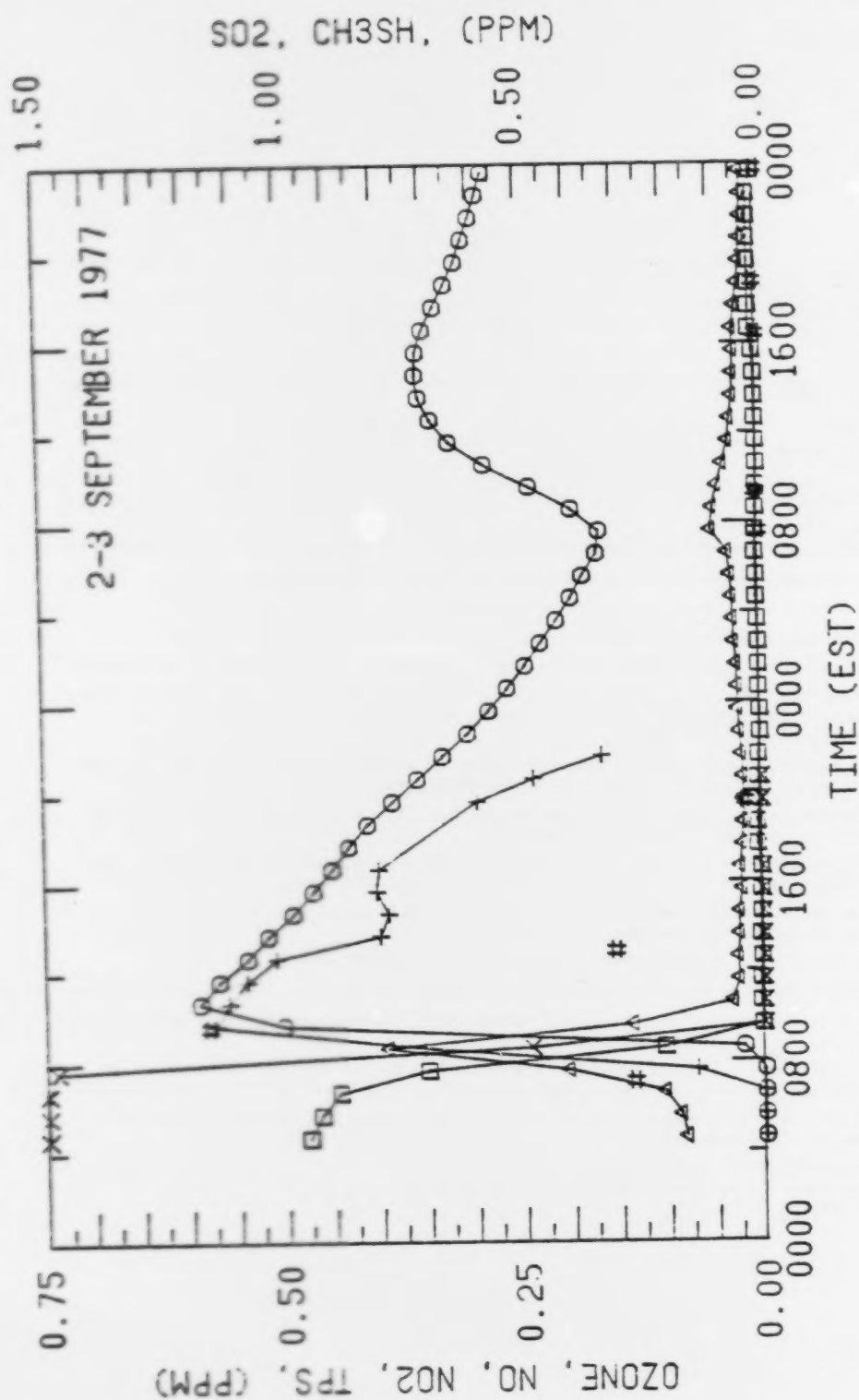


Figure 16. Concentration-time profiles of various reactants and products for the 2 and 3 September 1977 CH₃SH-NO_x experiment conducted in RTI Chamber No. 4. Target initial conditions: 2.0 ppmC CH₃SH and 0.5 ppm NO_x. Symbol key: (o) O₃; (□) NO; (Δ) NO₂, (x) CH₃SH; (+) SO₂; and (#) TPS.

Peaks tentatively identified as MN were found in the experiments conducted with CH_3SH on both 26 August and 2 September. PAN was not detected in these experiments. The retention time of EN was too long in these experiments to permit its resolution. The formation of either PAN or EN is unlikely in view of the chemical structure of CH_3SH . The tentative identification of MN suggests that the photooxidation of methanethiol involves cleavage of the methyl-sulfur bond which, in the presence of air and NO_x leads to the formation of MN.

A nitrogen mass balance was estimated for each experiment based on chemiluminescent NO_x concentrations determined initially and again during the 1700 EST hour of the first day. The nitrogen balances were extremely poor for the $\text{CH}_3\text{SH}-\text{NO}_x$ experiments--much worse than for the propene- NO_x experiments. For the four $\text{CH}_3\text{SH}-\text{NO}_x$ experiments the fraction of initial NO_x that could be accounted for ranged from 0.03 to 0.15. This fraction generally increased with increasing HC/NO_x ratios (i.e., decreasing NO_x concentrations). A reduction in the accountable NO_x was associated with an increase in maximum ozone concentrations in three of four cases. The unaccountable product nitrogen may be nitric acid or other undetermined nitrogen-containing species. The fate of the NO_x in photochemically reacting systems is largely unknown.

Initially, the concentrations of both total sulfur and CH_3SH exceeded the linear range of the sulfur analyzer. The test species, CH_3SH , was consumed very rapidly during these experiments, and concentrations fell to within the measureable range after only an hour of irradiation. The concentrations of CH_3SH that remained unreacted at the 1700 EST hour of the first day approached zero in three cases and was only 0.17 ppm in the fourth case. At target HC/NO_x ratios of 2, 4, and 10 the CH_3SH had been essentially consumed by 1100 EST; whereas, at a target ratio of 20 it persisted throughout the day. Inspection of the times to one-half consumption of CH_3SH also indicates that the disappearance rate of CH_3SH was dependent on the initial HC/NO_x ratio--increasing with decreasing ratios.

In each of the four experiments sulfur dioxide was found as a product of the photooxidation of CH_3SH in the presence of NO_x . Sulfur dioxide maxima exceeded 1.0 ppm and occurred between the 0900 and 1100 EST hours. A maximum SO_2 concentration first occurred at the target HC/NO_x ratio of 4.

In contrast to the behavior of $[O_3]_{\max}$, there was no apparent relationship between $[SO_2]_{\max}$ and initial HC/NO_x ratios. For the four experiments the largest $[SO_2]_{\max}$ exceeded 1.5 ppm and was achieved at the target initial HC/NO_x ratio of 10.

Moderate quantities of condensation nuclei were produced on the first day. Maximum CN concentrations ranged from 23,000 to 34,000 cm⁻³ and occurred during the 0800 EST hour. In addition, the CN maxima displayed no apparent trends with HC/NO_x ratio.

The conversion of methanethiol to particulate sulfur was rapid, and a considerable portion of the reacted CH₃SH was converted to particulate sulfur. Maximum concentrations occurred before 1100 EST and displayed a similar dependence on HC/NO_x ratio as that of maximum ozone concentrations. The maximum TPS concentrations ranged from 180 to 760 µg/m³ or the equivalent of 0.14 to 0.58 ppm of sulfur. The ratio of product sulfur as particulate to the total accountable reacted sulfur [(TPS) plus (SO₂)] was determined for each experiment. This ratio was based on data collected during or interpolated for the hour of occurrence of the maximum SO₂ concentration and permits an assessment of the distribution of accountable product sulfur between the gas and particulate phases. This fraction ranged from 0.06 to 0.34 and displayed similar trends with HC/NO_x ratios as were observed for $[O_3]_{\max}$. The largest $[TPS]_{\max}$, 0.58 ppmS, was achieved at the target HC/NO_x ratio of 4. Under these conditions both the $[SO_2]_{\max}$ and the $[TPS]_{\max}$ occurred at 0938 EST. Thus, after less than four hours of irradiation, most of the target initial 2 ppmS of CH₃SH had disappeared and 87 percent was measured as products. Of the 1.73 ppmS that could be accounted for, 34 percent was as particulate sulfur and the remainder was as SO₂. At the other HC/NO_x ratios, particulate sulfur comprised smaller percentages of the accountable product sulfur.

Data presented in the appendix indicate that both SO₂ and TPS concentrations decayed rapidly from their maximum levels during the afternoon and evening hours of the first day. These observations were made not only for CH₃SH but for many of the other sulfur-containing test species. They are discussed in more detail in other sections of this report. The mixing fans operated continuously during these experiments. It is likely that deposition

on the chamber walls was a major factor that influenced the measured concentrations of both SO_2 and TPS. This deposition was undoubtedly enhanced by the turbulence induced by the mixing fans. Poor definition of these processes hindered estimates of sulfur mass balances in all experiments of the current project. Future experiments should be performed such that mechanical mixing is conducted briefly to mix the reactants and is then terminated.

The second day, 3 September, was sunny with 80 percent sunshine and a cumulative daily solar radiation of 529 cal cm^{-2} . Second-day maximum TPS concentrations were low, accounting for 2.8 to $16.7 \mu\text{g/m}^3$ or 0.002 to 0.013 ppmS . In three cases $[\text{TPS}]_{\text{max}}$ were $5 \mu\text{g/m}^3$ or less. The case with $16.7 \mu\text{g/m}^3$ occurred at the target HC/NO_x ratio of 20, where first-day conversion of both CH_3SH and NO_x were observed to have been incomplete. Thus, the slight enhancement of TPS in this case may have resulted from second-day reaction of residual CH_3SH , NO_x , and reaction products from the first day.

Although second-day SO_2 concentration data were insufficient to define net concentrations, significant quantities of SO_2 as well as CN and O_3 were measured. At the target HC/NO_x ratio of 20, where the first-day conversion of reactants had been incomplete, a second-day SO_2 maximum of 0.398 ppm was achieved. Second-day CN maxima generally exceeded first-day levels by a factor of 2 or more, ranging from $52,000$ to $140,000 \text{ cm}^{-3}$. The largest second-day $[\text{CN}]_{\text{max}}$ occurred at the target HC/NO_x ratio of 4 and decreased as this ratio was moved away from 4. Net ozone concentrations ranged from 0.19 to 0.38 ppm and increased with increasing HC/NO_x ratios. The largest net ozone concentration was achieved at the target HC/NO_x ratio of 20, where first-day conversion of both CH_3SH and NO_x had been the least complete. In addition, both the net and maximum ozone concentrations at this condition exceeded the first-day maximum ozone concentration; whereas, at target HC/NO_x ratios of 2, 4, and 10 the net ozone concentrations were substantially less than first-day maxima.

Methyl Sulfide

Mixtures of methyl sulfide and NO_x were irradiated on 28 and 29 September 1977. On 28 September the cumulative daily solar radiation was 414 cal cm^{-2} with 64 percent of the possible minutes of direct sunshine and a maximum temperature of 26.1° C . Selected results from the $\text{CH}_3\text{SCH}_3\text{-NO}_x$ experiments

are summarized in Table 22. Concentration-time profiles of various reactants and products for the experiment conducted in Chamber No. 3 are presented in Figure 17.

The photochemical behavior of irradiated mixtures of NO_x and CH_3SCH_3 was similar in many respects to that of irradiated mixtures of NO_x and hydrocarbons such as propene. In each of these experiments conversion of NO to NO_2 was rapid. Approximately 1.5 hours of irradiation were required to achieve NO-NO_2 crossover, and the maximum NO_2 concentrations occurred during the 0800 EST hour. The duration of irradiation required to achieve crossover decreased with increasing initial HC/NO_x ratios. Crossover occurred first at the target HC/NO_x ratio of 20. In contrast to the propene- NO_x system, however, the time to crossover was not strongly dependent on HC/NO_x ratio.

Ozone accumulated during each experiment. Maximum concentrations were dependent on the initial HC/NO_x ratio (i.e., initial NO_x concentration). Ozone maxima ranged from 0.32 to 0.86 ppm and generally occurred between the 0900 and 1100 hours. A maximum ozone concentration was first achieved in Chamber No. 4 at the target HC/NO_x ratio of 4. For the four experiments the largest maximum ozone concentration was 0.86 ppm and occurred at the target initial HC/NO_x ratio of 2. Maximum ozone concentrations decreased with increasing initial HC/NO_x ratio (i.e., decreasing NO_x concentration). These reductions in maximum ozone concentrations are also associated with the small reductions in the times to NO-NO_2 crossover noted earlier.

Neither PAN nor EN concentration data were available for these experiments. Their formation is unlikely in view of the chemical structure of CH_3SCH_3 . Methyl nitrate was detected in two of the four experiments, and data were not available for the other two. The larger MN concentration occurred at the target HC/NO_x ratio of 2. The tentative identification of MN suggests that the photooxidation of methyl sulfide is similar to that of methanethiol. Cleavage of the methyl-sulfur bond may occur and, in the presence of air and NO_x , may lead to the formation of MN.

A nitrogen mass balance was estimated for each experiment based on chemiluminescent NO_x concentrations determined initially and again during the 1700 EST hour of the first day. The nitrogen balances were worse than for the propene- NO_x experiments and similar to those of the $\text{CH}_3\text{SH-NO}_x$ experiments. For the four $\text{CH}_3\text{SCH}_3\text{-NO}_x$ experiments the fraction of initial NO_x

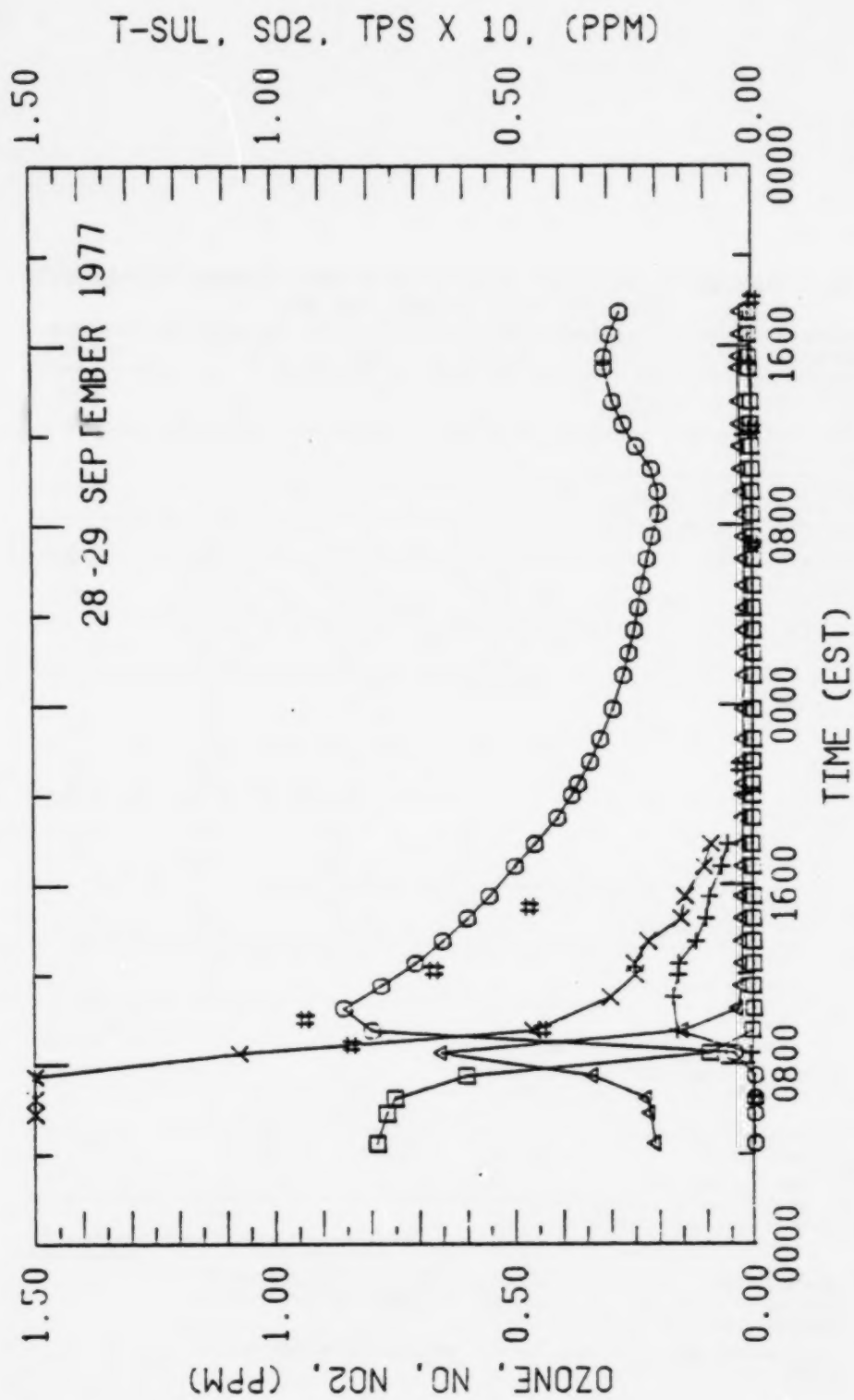


Figure 17. Concentration-time profiles of various reactants and products for the 28 and 29 September 1977 $\text{CH}_3\text{SCH}_3\text{-NO}_x$ experiment conducted in RTI Chamber No. 3. Target initial conditions: 2.0 ppmC CH_3SCH_3 and 1.0 ppm NO_x . Symbol key: (o) O_3 ; ($\square$) NO ; (Δ) NO_2 ; (x) Total Sulfur; (+) SO_2 ; and (#) TPS .

TABLE 22. SUMMARY OF SELECTED RESULTS FROM SMOG CHAMBER EXPERIMENTS
CONDUCTED WITH CH₃SCH₃ AND NO_x

TEST COMPOUND ^{a/}	DATE ^{b/}	T _{max} ^{c/}	%SS ^{d/}	CU-SR ^{e/}	SUNRISE ^{f/}
Methyl Sulfide, CH ₃ SCH ₃	9-28-77 9-29-77	26.1 23.9	64 13	414 366	6.03
SMOG CHAMBER NUMBER		3	4	1	2
FIRST DAY PARAMETERS					
Target Initial HC/NO _x (ppmC/ppm)		2	4	10	20
Time of NO-NO ₂ Crossover, (hrs EST)		7.79	7.72	7.50	7.41
[NO ₂] _{max} , ppm		0.651	0.263	0.136	0.049
Time of [NO ₂] _{max} , (hrs EST)		8.47	8.63	8.13	8.30
[O ₃] _{max} , ppm		0.856	0.645	0.402	0.318
Time of [O ₃] _{max} , (hrs EST)		10.47	9.63	10.13	11.30
[PAN] _{max} , ppm		ND	ND	ND	ND
Time of [PAN] _{max} , (hrs EST)		NA	NA	NA	NA
[MN] ppm ^{g/}		0.032	ND	0.017	ND
[EN] ppm		ND	ND	ND	ND
[NO _x] _{initial} ^{h/}		0.974	0.497	0.194	0.091
[NO _x] @ 1700 EST		0.028	0.018	0.014	0.014
fNO _x @ 1700 EST ^{i/}		0.029	0.036	0.072	0.154
[CH ₃ SCH ₃] @ 1700 EST ^{j/}		0.045	0.197	0.496	0.742
Time of [CH ₃ SCH ₃] _k , (hrs EST) ^{k/}		8.77	8.96	9.74	12.93
[SO ₂] _{max} , ppm		0.169	0.108	tr	tr
Time of [SO ₂] _{max} , (hrs EST)		10.47	9.63	NA	NA
[TPS] _{max} , µg/m ³		122.5	97.4	151.3	117.8
(ppmS)		0.094	0.075	0.116	0.090
Time of [TPS] _{max} , (hrs EST)		10.47	12.63	8.13	8.30
R ^{l/}		0.36	0.38	ND	ND
[CN] _{max} , cm ⁻³		36,000	34,000	9,100	11,000
Time of [CN] _{max} , (hrs EST)		9.47	8.63	8.13	9.30
Night-time O ₃ Half-Life (hrs) ^{m/}		13	7	3 ^{n/}	3 ^{n/}

(continued)

NOTES: Abbreviations: ND = no data are available; NA = not applicable;
0 = not detected; tr = detected, but not quantified; X = concentration decreased, no maximum observed.

The appendix should be consulted for additional data that are not summarized in this table.

TABLE 22. (continued)

SMOG CHAMBER NUMBER	3	4	1	2
SECOND DAY PARAMETERS				
$[O_3]_{\max}$, ppm	0.308	0.265	0.189	0.212
ΔO_3 , ppm ^{a/}	0.112	0.188	0.181	0.199
$[SO_2]_{\max}$, ppm	ND	ND	ND	ND
ΔSO_2 , ppm ^{a/}	NA	NA	NA	NA
$[TPS]_{\max}$, $\mu g/m^3$	0	0	0	0
(ppmS)	0	0	0	0
$[CN]_{\max}$, cm^{-3}	5,300	1,700	2,700	2,600

^{a/} Target initial concentration 2.0 ppmC, 1.0 ppm (V/V), or 1.0 ppmS.

^{b/} Dates of first and second days of the experiment.

^{c/} Daily maximum temperature in °C.²⁹

^{d/} Duration of direct solar radiation reported as percent of possible minutes of sunshine.²⁹

^{e/} Cumulative daily solar radiation expressed in Langleys ($cal\ cm^{-2}$); note that the second-day value is the cumulative solar radiation on that day until the experiment was terminated--usually 1700 EST.

^{f/} Time of sunrise in hours (EST); since the times of sunrise are approximately the same for both days, the time is given for the first day only.

^{g/} Daily median concentrations of species tentatively identified to be methyl and ethyl nitrate; they are not listed in the appendix.

^{h/} The initial $[NO]$ is taken to be the concentration that existed at approximately the time of sunrise; the table entry has NOT been corrected for possible interferences.

^{i/} Fraction of initial NO remaining at the 1700 EST hour calculated from NO_x concentrations as determined by the chemiluminescent NO_x analyzer.

^{j/} Concentration of accountable test compound at the 1700 EST hour.

^{k/} Estimate of the time at which approximately one-half of the test compound was consumed.

^{l/} Ratio of product sulfur as particulate to the total accountable reacted sulfur at the time of $[SO_2]_{\max}$: $(([TPS])/([TPS]+[SO_2]))$.

^{m/} Estimate of ozone half-life based on data collected during the 2000 EST hour of the first day and the 0400 EST hour of the second day: $t_{1/2} \approx 5.545/\ln([O_3]_{2000}/[O_3]_{0400})$.

^{n/} This half-life may be suspect, since ozone concentrations smaller than 0.1 ppm were involved in its determination.

^{o/} Net concentration on the second day is the difference between the second-day maximum concentration and the preceding minimum concentration: $\Delta O_3 = [O_3]_{\max} - [O_3]_{\min}$ and $\Delta SO_2 = [SO_2]_{\max} - [SO_2]_{\min}$.

that could be accounted for ranged from 0.03 to 0.15. This fraction generally increased with increasing initial HC/NO_x ratios (i.e., decreasing initial NO_x concentrations) and was also associated with decreasing maximum ozone concentrations. The unaccountable product nitrogen may be nitric acid or other undetermined nitrogen-containing species. The fate of NO_x in photochemically reacting systems is largely unknown.

Initially, the total sulfur concentration exceeded the linear range of the sulfur analyzer. The test species was consumed rapidly during these experiments, and within a few hours after sunrise its concentration could be approximated by the difference between the total sulfur and SO₂ concentrations. Estimates were made of concentrations of CH₃SCH₃ that remained unreacted at the 1700 EST hour of the first day. The ordering of the concentrations of remaining CH₃SCH₃ was similar to that observed earlier for the fraction of remaining NO_x. In both cases, the fractions of unreacted reactants increased with increasing initial HC/NO_x ratios. For the four experiments the concentration of initial CH₃SCH₃ that remained ranged from 0.05 to 0.74 ppm. At the target HC/NO_x ratio of 2, the smallest amount of the initially present CH₃SCH₃ could be accounted for at the 1700 EST hour, and thus, at this condition conversion to product species was the most nearly complete. Inspection of the times to one-half consumption of CH₃SCH₃ also indicates that the CH₃SCH₃ disappearance rate was dependent on the initial HC/NO_x ratio---increasing with decreasing ratios.

In each of the four experiments sulfur dioxide was found as a product of the photooxidation of CH₃SCH₃ in the presence of NO_x. Concentrations sufficiently high for quantification were found in only two of these experiments. Maximum concentrations were dependent on the initial HC/NO_x ratio (i.e., initial NO_x concentration). Sulfur dioxide maxima ranged from trace quantities to 0.17 ppm and generally occurred before 1100 EST. For the four experiments the largest maximum SO₂ concentration was 0.17 ppm and was achieved at the target initial HC/NO_x ratio of 2. The apparent relationship between [SO₂]_{max} and initial HC/NO_x ratio was similar to that observed earlier for another reaction product, ozone. In both cases maximum concentrations decreased with increasing HC/NO_x ratio (i.e., decreasing NO_x concentrations), although the absolute concentrations of the O₃ maxima far exceeded the SO₂ maxima.

Moderate quantities of condensation nuclei were produced on the first day. Maximum concentrations ranged from 9,100 to 36,000 cm^{-3} and generally occurred early, before 1000 EST. Maximum CN concentrations generally decreased with increasing initial HC/NO_x ratios. For the four experiments the largest maximum CN concentration occurred at the target HC/NO_x ratio of 2.

Conversion of CH_3SCH_3 to particulate sulfur was fairly rapid. A small to moderate portion of the reacted test species was detected as particulate sulfur. Maximum TPS concentrations generally occurred during the morning of the first day. They displayed no apparent trends with initial HC/NO_x ratio. These maxima ranged from 97 to 151 $\mu\text{g}/\text{m}^3$ and correspond to the equivalent of 0.075 to 0.116 ppm of sulfur.

The ratio of product sulfur as particulate to the total accountable reacted sulfur [(TPS) plus (SO_2)] was determined for each experiment. This ratio was based on data collected during or interpolated for the hour of occurrence of the maximum SO_2 concentration and permits an assessment of the distribution of accountable product sulfur between the gas and particulate phases. Data were available to permit an assessment of this ratio in only two of the four cases. These results, 0.36 and 0.38, suggest that for CH_3SCH_3 almost 40 percent of the accountable product sulfur existed as particulate. In addition, results in the appendix suggest that a substantial portion of the product sulfur cannot be accounted for.

The second day was mostly cloudy with only 13 percent sunshine. As a result, moderate quantities of O_3 were generated, but only small amounts of CN, SO_2 and TPS were observed on the second day. Both second-day maximum and net ozone concentrations were substantially less than the first-day maxima, and net ozone levels ranged from 0.11 to 0.20 ppm. Second-day $[\text{CN}]_{\text{max}}$ were much less than their respective first-day values and in no case exceeded 6000 cm^{-3} . The few SO_2 concentration data that were available on the second day indicated small but detectable levels of SO_2 . Particulate sulfur was not detected in any chamber on the second day.

Methyl Disulfide

Mixtures of methyl disulfide and NO_x were irradiated on 5 and 6 October 1977. On 5 October the cumulative daily solar radiation was 440 cal cm^{-2}

with 99 percent of the possible minutes of direct sunshine and a maximum temperature of 23.9° C. Selected results from the $(\text{CH}_3\text{S})_2\text{-NO}_x$ experiments are summarized in Table 23. Concentration-time profiles of various reactants and products for the experiment conducted in Chamber No. 3 are presented in Figure 18.

The photochemical behavior of irradiated mixtures of NO_x and $(\text{CH}_3\text{S})_2$ was similar in many respects to that of irradiated mixtures of NO_x and hydrocarbons such as propene. In each of the $(\text{CH}_3\text{S})_2\text{-NO}_x$ experiments conversion of NO to NO_2 was rapid. The disulfides, methyl and ethyl, displayed the most rapid conversion of NO to NO_2 of all the species tested in the current study. For the experiments conducted with methyl disulfide approximately 0.82 hours of irradiation were required to achieve NO- NO_2 crossover, and the maximum NO_2 concentration occurred during the 0700 EST hour. In contrast to the propene- NO_x system, the time to crossover displayed no apparent trends with the initial HC/ NO_x ratio. As with ethyl disulfide, however, crossover occurred first at the target HC/ NO_x ratio of 10.

Ozone accumulated during each experiment. Maximum concentrations and the times required to achieve them were dependent on the initial HC/ NO_x ratio (i.e., initial NO_x concentration). Ozone maxima ranged from 0.11 to 0.39 ppm. As was also observed for methanethiol, an ozone maximum occurred first at the target initial HC/ NO_x ratio of 4. For the remaining experiments, the ozone maxima occurred later in the day, during the 1400 and 1500 EST hours. For the four experiments the largest maximum ozone concentration was 0.39 ppm and was achieved at the target initial HC/ NO_x ratio of 2. Maximum ozone concentrations decreased with increasing initial HC/ NO_x ratio (i.e., decreasing NO_x concentration).

Neither PAN nor EN were detected in these experiments. Their formation is unlikely in view of the chemical structure of $(\text{CH}_3\text{S})_2$. Methyl nitrate, however, was detected in each experiment. Median concentrations of MN were dependent on the initial HC/ NO_x ratio. The largest MN concentration for the four experiments occurred at the target HC/ NO_x ratio of 2, and concentrations decreased with increasing initial ratios (i.e., decreasing initial NO_x concentrations). The tentative identification of MN suggests that the photooxidation of methyl disulfide is similar to that of the methane thiol and methyl sulfide. Cleavage of the methyl-sulfur bond may occur and, in the presence of air and NO_x , may lead to the formation of MN.

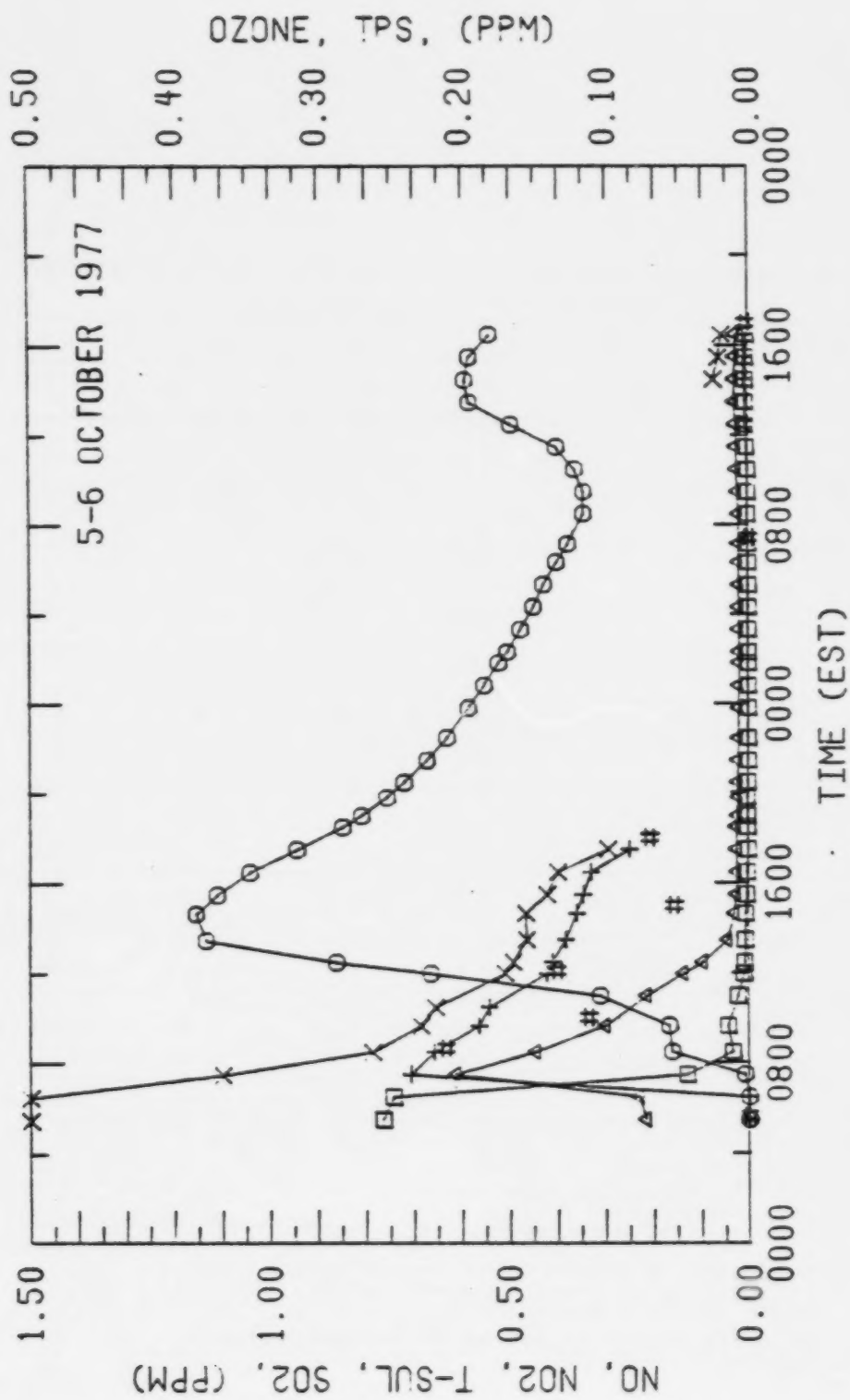


Figure 18. Concentration-time profiles of various reactants and products for the 5 and 6 October 1977 (CH₃S)₂-NO_x experiment conducted in RTI Chamber No. 3. Target initial conditions: 2.0 ppmC (CH₃S)₂ and 1.0 ppm NO_x. Symbol key: (o) O₃; (□) NO; (Δ) NO₂; (x) Total Sulfur; (+) SO₂; and (#) TPS.

TABLE 23. SUMMARY OF SELECTED RESULTS FROM SMOG CHAMBER EXPERIMENTS
CONDUCTED WITH $(\text{CH}_3\text{S})_2$ AND NO_x

TEST COMPOUND ^{a/}	DATE ^{b/}	T_{max} ^{c/}	$\% \text{SS}$ ^{d/}	CU-SR ^{e/}	SUNRISE ^{f/}
Methyl Disulfide ($\text{CH}_3\text{S})_2$	10-5-77	23.9	99	440	6.15
	10-6-77	24.4	29	315	
SMOG CHAMBER NUMBER		3	4	1	2
FIRST DAY PARAMETERS					
Target Initial HC/NO_x (ppmC/ppm)		2	4	10	20
Time of $\text{NO}-\text{NO}_2$ Crossover, (hrs EST)		6.99	7.14	6.85	6.90
$[\text{NO}_2]_{\text{max}}$, ppm		0.612	0.290	0.102	0.050
Time of $[\text{NO}_2]_{\text{max}}$, (hrs EST)		7.47	7.63	7.13	7.30
$[\text{O}_3]_{\text{max}}$, ppm		0.385	0.311	0.129	0.112
Time of $[\text{O}_3]_{\text{max}}$, (hrs EST)		14.63	12.63	14.30	15.30
$[\text{PAN}]_{\text{max}}$, ppm		0	0	0	0
Time of $[\text{PAN}]_{\text{max}}$, (hrs EST)		NA	NA	NA	NA
$[\text{MN}]$ ppm ^{g/}		0.025	0.015	0.007	0.001
$[\text{EN}]$ ppm		0	0	0	0
$[\text{NO}_x]_{\text{initial}}$ ^{h/}		0.972	0.486	0.193	0.089
$[\text{NO}_x]$ @ 1700 EST		0.025	0.017	0.013	0.011
fNO_x @ 1700 EST ^{i/}		0.026	0.035	0.067	0.124
$[(\text{CH}_3\text{S})_2]$ @ 1200 EST ^{j/}		0.081	0.042	0.104	0.117
Time of $[(\text{CH}_3\text{S})_2]_{\text{max}}$, (hrs EST) ^{k/}		7.09	7.18	7.89	9.42
$[\text{SO}_2]_{\text{max}}$, ppm		0.707	0.495	0.662	0.514
Time of $[\text{SO}_2]_{\text{max}}$, (hrs EST)		7.47	7.63	9.18	10.80
$[\text{TPS}]_{\text{max}}$, $\mu\text{g}/\text{m}^3$		276.3	182.6	502.4	177.4
(ppmS)		0.211	0.140	0.384	0.136
Time of $[\text{TPS}]_{\text{max}}$, (hrs EST)		8.47	8.77	8.13	10.80
R ^{l/}		0.17	0.18	0.30	0.21
$[\text{CN}]_{\text{max}}$, cm^{-3}		24,000	24,000	27,000	22,000
Time of $[\text{CN}]_{\text{max}}$, (hrs EST)		13.47	12.63	10.63	12.30
Night-time O_3 Half-Life (hrs) ^{m/}		12	15	4 ^{n/}	6 ^{n/}

NOTES: Abbreviations: ND = no data are available; NA = not applicable;
0 = not detected; tr = detected, but not quantified; X = concentration decreased, no maximum observed.

The appendix should be consulted for additional data that are not summarized in this table.

(continued)

TABLE 23. (continued)

SMOG CHAMBER NUMBER	3	4	1	2
SECOND DAY PARAMETERS				
$[O_3]_{\max}$, ppm	0.197	0.166	0.114	0.125
ΔO_3 , ppm ^{a/}	0.082	0.057	0.107	0.110
$[SO_2]_{\max}$, ppm	tr	tr	0.083	tr
ΔSO_2 , ppm ^{a/}	NA	NA	NA	NA
$[TPS]_{\max}$, $\mu\text{g}/\text{m}^3$	4.7	3.2	8.9	4.5
(ppmS)	0.004	0.002	0.007	0.003
$[CN]_{\max}$, cm^{-3}	750	810	1,000	690

^{a/} Target initial concentration 2.0 ppmC, 1.0 ppm (V/V), or 2.0 ppmS.

^{b/} Dates of first and second days of the experiment.

^{c/} Daily maximum temperature in °C.²⁸

^{d/} Duration of direct solar radiation reported as percent of possible minutes of sunshine.²⁸

^{e/} Cumulative daily solar radiation expressed in Langleys (cal cm^{-2}); note that the second-day value is the cumulative solar radiation on that day until the experiment was terminated--usually 1700 EST.

^{f/} Time of sunrise in hours (EST); since the times of sunrise are approximately the same for both days, the time is given for the first day only.

^{g/} Daily median concentrations of species tentatively identified to be methyl and ethyl nitrate; they are not listed in the appendix.

^{h/} The initial $[NO_x]$ is taken to be the concentration that existed at approximately the time of sunrise; the table entry has NOT been corrected for possible interferences.

^{i/} Fraction of initial NO_x remaining at the 1700 EST hour calculated from NO_x concentrations as determined by the chemiluminescent NO_x analyzer.

^{j/} Concentration of accountable test compound at the 1200 EST hour.

^{k/} Estimate of the time at which approximately one-half of the test compound was consumed.

^{l/} Ratio of product sulfur as particulate to the total accountable reacted sulfur at the time of $[SO_2]_{\max}$: $([TPS]/([TPS]+[SO_2]))$.

^{m/} Estimate of ozone half-life based on data collected during the 2000 EST hour of the first day and the 0400 EST hour of the second day: $t_{1/2} = 5.543/\ln ([O_3]_{2000}/[O_3]_{0400})$.

^{n/} This half-life may be suspect, since ozone concentrations smaller than 0.1 ppm were involved in its determination.

^{o/} Net concentration on the second day is the difference between the second-day maximum concentration and the preceding minimum concentration: $\Delta O_3 = [O_3]_{\max} - [O_3]_{\min}$ and $\Delta SO_2 = [SO_2]_{\max} - [SO_2]_{\min}$.

A nitrogen mass balance was estimated for each experiment based on chemiluminescent NO_x concentrations determined initially and again during the 1700 EST hour of the first day. The nitrogen balances were worse than for the propene- NO_x experiments and similar to those of the $\text{CH}_3\text{SH-NO}_x$ and $\text{CH}_3\text{SCH}_3\text{-NO}_x$ experiments. For the four $(\text{CH}_3\text{S})_2\text{-NO}_x$ experiments the fraction of initial NO_x that could be accounted for ranged from 0.03 to 0.12. This fraction generally increased with increasing initial HC/NO_x ratios (i.e., decreasing initial NO_x concentrations) and was also associated with decreasing maximum ozone concentrations. These results suggest that the presence of a $\text{CH}_3\text{-}$ or $\text{CH}_3\text{S-}$ group in the test species renders as unaccountable at the end of the first day, at least 85 percent of the initially present NO_x . The unaccountable product nitrogen may be nitric acid or other undetermined nitrogen-containing species. The fate of NO_x in photochemically reacting systems is largely unknown.

Initially, the total sulfur concentration exceeded the linear range of the sulfur instrument. The test species, $(\text{CH}_3\text{S})_2$, was consumed rapidly during these experiments, and by the 0900 EST hour its concentration could be approximated by the difference between the total sulfur and the SO_2 concentrations. Since reaction was very rapid, estimates were made of the concentrations of $(\text{CH}_3\text{S})_2$ that remained unreacted at the 1200 EST hour of the first day. With a single exception, the ordering of the concentrations of remaining $(\text{CH}_3\text{S})_2$ was similar to that observed earlier for the fraction of remaining NO_x (at the 1700 EST hour). In both cases the fractions of unreacted reactants increased with increasing initial HC/NO_x ratios. For the four experiments the concentrations of remaining $(\text{CH}_3\text{S})_2$ ranged from 0.04 to 0.12 ppm. Inspection of the times to one-half consumption of $(\text{CH}_3\text{S})_2$ also indicates that the $(\text{CH}_3\text{S})_2$ disappearance rate was dependent on the initial HC/NO_x ratio--increasing with decreasing ratios.

In each of the four experiments sulfur dioxide was found as a product of the photooxidation of $(\text{CH}_3\text{S})_2$ in the presence of NO_x . Maximum concentrations and their times of occurrence were dependent on the initial HC/NO_x ratio. Sulfur dioxide maxima ranged from 0.50 to 0.71 ppm. Maximum concentrations were first achieved during the 0700 EST hour at target ratios of 2 and 4. The times required to reach $[\text{SO}_2]_{\text{max}}$ increased with increasing HC/NO_x ratios. The largest $[\text{SO}_2]_{\text{max}}$, 0.71 ppm, occurred at the target HC/NO_x ratio of 2.

With a single exception, maximum SO_2 concentrations decreased with increasing initial HC/NO_x ratios. Other reaction products such as ozone and MN exhibited similar behavior in which decreasing maximum concentrations were associated with increasing HC/NO_x ratios.

Moderate quantities of condensation nuclei were produced on the first day. Maximum concentrations generally occurred between the 1000 and 1300 EST hours. They were not appreciably different for the four experiments, ranging from 22000 to 27000 cm^{-3} . The largest $[\text{CN}]_{\text{max}}$ occurred at the target HC/NO_x ratio of 10.

Conversion of $(\text{CH}_3\text{S})_2$ to particulate sulfur was rapid. Maximum TPS concentrations were achieved before 1100 EST and, in three of four cases, occurred during the 0800 EST hour. The maximum TPS concentrations ranged from 177 to 502 $\mu\text{g}/\text{m}^3$ and correspond to the equivalent of 0.14 to 0.38 ppmS. Based on the narrow spread among the SO_2 maxima and on the ordering of the maximum ozone concentrations, the maximum TPS concentrations might be expected to decrease with increasing initial HC/NO_x ratios. This was the case, with a single exception: at the target HC/NO_x ratio of 10, where the largest $[\text{TPS}]_{\text{max}}$, 502 $\mu\text{g}/\text{m}^3$, was determined. This value appears to be unusually high. However, since no reason has been identified to invalidate the value, it was retained.

The ratio of product sulfur as particulate to the total accountable reacted sulfur ($[\text{TPS}]$ plus $[\text{SO}_2]$) was determined for each experiment. This ratio was based on data collected during or interpolated for the hour of occurrence of the maximum SO_2 concentration, and it permits an assessment of the distribution of accountable product sulfur between the gas and particulate phases. For the $(\text{CH}_3\text{S})_2\text{-NO}_x$ system this ratio ranged from 0.17 to 0.30. The maximum ratio, 0.30, occurred at the target HC/NO_x ratio of 10, as did the $[\text{TPS}]_{\text{max}}$, and decreased as the target HC/NO_x ratio was moved away from 10. Thus, most of the accountable product sulfur existed as SO_2 . In addition, results in the appendix suggest that a substantial portion of the product sulfur cannot be accounted for.

Although only 29 percent sunshine occurred on the second day, the cumulative daily solar radiation on this day was substantial, 315 cal cm^{-2} . Second-day maximum TPS and CN concentrations were low. Maximum TPS concen-

trations ranged from 3.2 to 8.9 $\mu\text{g}/\text{m}^3$ or 0.003 to 0.007 ppmS on the second day, and maximum CN concentrations did not exceed 1000 cm^{-3} . The largest secondary maximum concentrations of both TPS and CN occurred at the target HC/NO_x ratio of 10. Sulfur dioxide concentration data were available for only 3 hours on the second day. Thus, it is uncertain whether the maxima from the available data were identical to the daily maxima. Nonquantifiable trace amounts were found in three of the four chambers. At the target HC/NO_x ratio of 10, however, SO₂ was determined, and the largest concentration was found to be 0.083 ppm. Second-day ozone maxima were less than the corresponding first-day levels in three of four cases. At the target HC/NO_x ratio of 20 the second-day maximum ozone concentration exceeded the first-day value. Net ozone concentrations were less than the first-day maxima and ranged from 0.06 to 0.11 ppm. Although the net ozone concentrations displayed no clear trends with respect to the various initial conditions, the largest net ozone concentration was achieved at the target HC/NO_x ratio of 20, where first-day conversion of NO_x had been the least complete.

Methyl Ethyl Sulfide

Mixtures of methyl ethyl sulfide and NO_x were irradiated on 10 and 11 October 1977, and the experiments were repeated on 9 and 10 November. On 10 October the cumulative daily solar radiation was 377 cal cm^{-2} with 76 percent of the possible minutes of direct sunshine and a maximum temperature of 18.3° C. On 9 November, although the percent of possible minutes of direct sunshine was similar at 71 percent, seasonal changes reduced the possible duration of sunshine and hence the cumulative solar radiation to 280 cal cm^{-2} . In addition, 9 November, with a maximum temperature of 24.4° C, was slightly warmer than 10 October. Selected results from the CH₃SC₂H₅-NO_x experiments are summarized in Tables 24 and 25. As evidenced by comparison of the parameters listed in these tables, the results of experiments conducted on 10 October and 9 November were similar. In view of this comparison, the 10 October experiments were chosen for emphasis in the current discussion. Concentration-time profiles of various reactants and products for the 10 October experiment conducted in Chamber No. 3 are presented in Figure 19.

The photochemical behavior of irradiated mixtures of NO_x and CH₃SC₂H₅ was similar in many respects to that of irradiated mixtures of NO_x and hydrocarbons such as propene. In each of the CH₃SC₂H₅-NO_x experiments,

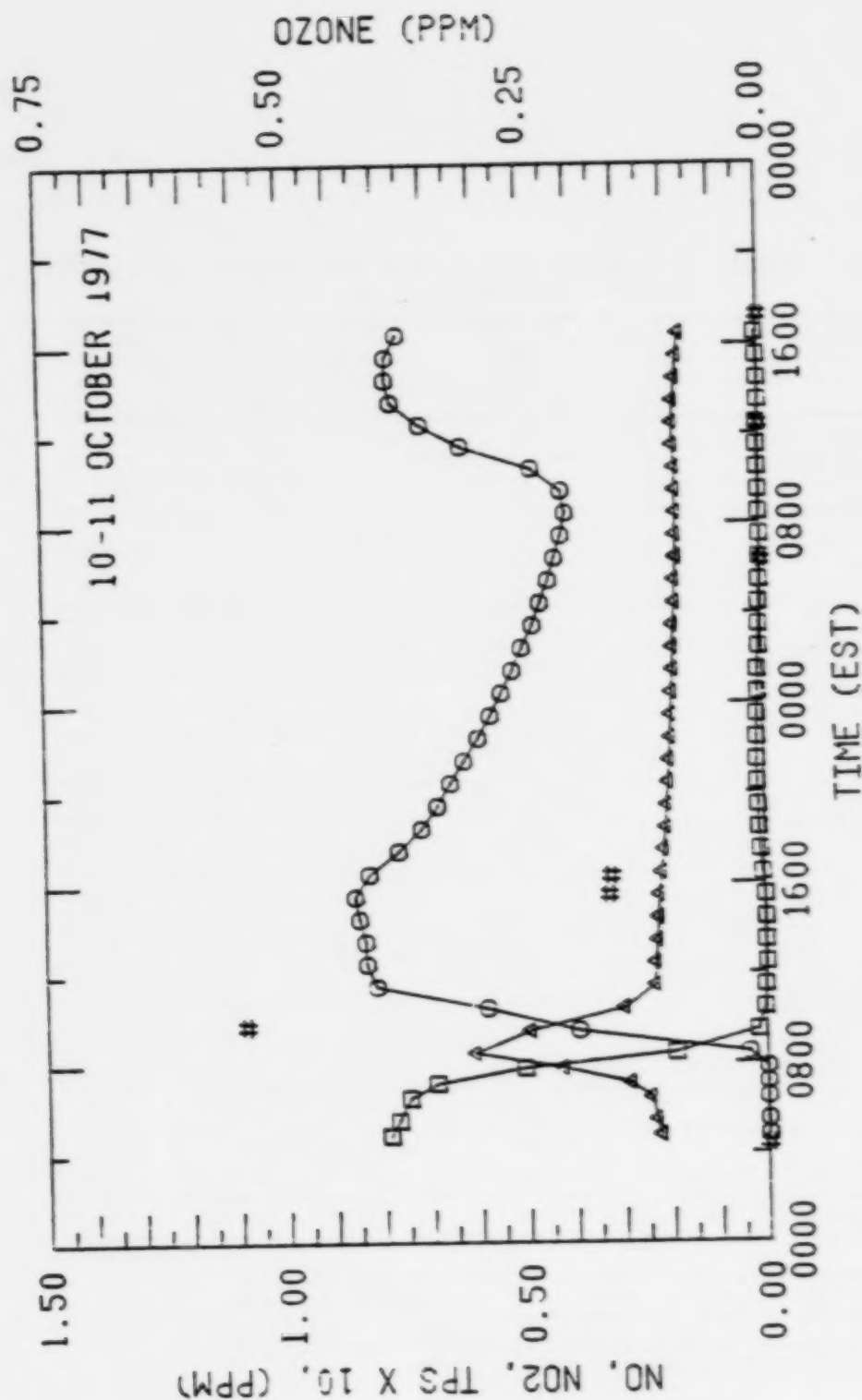


Figure 19. Concentration-time profiles of various reactants and products for the 10 and 11 October 1977 CH₃SC₂H₅-NO_x experiment conducted in RTI Chamber No. 3. Target initial conditions: 2.0 ppmC CH₃SC₂H₅ and 1.0 ppm NO_x. Symbol key: (o) O₃; (□) NO; (Δ) NO₂; and (#) TFS.

TABLE 24. SUMMARY OF SELECTED RESULTS FROM SMOG CHAMBER EXPERIMENTS
CONDUCTED WITH CH₃SC₂H₅ AND NO_x

TEST COMPOUND ^{a/}	DATE ^{b/}	T _{max} ^{c/}	%SS ^{d/}	CU-SR ^{e/}	SUNRISE ^{f/}
Methyl Ethyl Sulfide	10-10-77	18.3	76	377	6.23
CH ₃ SC ₂ H ₅	10-11-77	19.4	53	276	
SMOG CHAMBER NUMBER		3	4	1	2
FIRST DAY PARAMETERS					
Target Initial HC/NO _x (ppmC/ppm)		2	4	10	20
Time of NO-NO ₂ Crossover, (hrs EST)		7.91	7.76	7.65	7.55
[NO ₂] _{max} , ppm		0.611	0.316	0.117	0.052
Time of [NO ₂] _{max} , (hrs EST)		8.47	8.63	8.13	8.30
[O ₃] _{max} , ppm		0.428	0.274	0.185	0.138
Time of [O ₃] _{max} , (hrs EST)		15.47	10.63	10.13	9.30
[PAN] _{max} , ppm		0.113	0.062	0.021	0.019
Time of [PAN] _{max} , (hrs EST)		12.47	11.63	16.13	14.30
[MN] ppm ^{g/}		0.006	0.002	tr	0
[EN] ppm		0.007	0.004	0.001	0.001
[NO] _x initial ^{h/}		0.993	0.503	0.189	0.099
[NO] _x @ 1700 EST		0.222	0.120	0.056	0.040
fNO _x @ 1700 EST ^{i/}		0.224	0.239	0.296	0.404
[CH ₃ SC ₂ H ₅] @ 1700 EST ^{j/}		tr	tr	0.258	0.409
Time of [CH ₃ SC ₂ H ₅] _{1/2} (hrs EST) ^{k/}		8.95	9.04	9.63	12.05
[SO ₂] _{max} , ppm		0.079 ^{l/}	0.054 ^{l/}	tr	tr
Time of [SO ₂] _{max} , (hrs EST)		9.47	9.63	NA	NA
[TPS] _{max} , µg/m ³		141.9	79.2	73.2	31.5
(ppmS)		0.109	0.061	0.056	0.024
Time of [TPS] _{max} , (hrs EST)		9.47	9.63	9.13	9.30
R ^{1/}		0.58	0.53	ND	ND
[CN] _{max} , cm ⁻³		31,000	29,000	31,000	22,000
Time of [CN] _{max} , (hrs EST)		10.47	10.63	10.13	10.30
Night-time O ₃ Half-Life (hrs) ^{m/}		16	8 ^{n/}	3 ^{n/}	3 ^{n/}

(continued)

NOTES: Abbreviations: ND = no data are available; NA = not applicable;
0 = not detected; tr = detected, but not quantified; X = concentration decreased, no maximum observed.

The appendix should be consulted for additional data that are not summarized in this table.

TABLE 24. (continued)

SMOG CHAMBER NUMBER	3	4	1	2
SECOND DAY PARAMETERS				
$[O_3]_{\max}$, ppm	0.389	0.251	0.148	0.137
ΔO_3 , ppm ^{a/}	0.186	0.187	0.144	0.133
$[SO_2]_{\max}$, ppm	tr	tr	tr	tr
ΔSO_2 , ppm ^{a/}	NA	NA	NA	NA
$[TPS]_{\max}$, $\mu\text{g}/\text{m}^3$	0	0	0	0
(ppmS)	0	0	0	0
$[CN]_{\max}$, cm^{-3}	1,800	2,300	1,600	1,200

^{a/} Target initial concentration 2.0 ppmC, 0.67 ppm (V/V), or 0.67 ppmS.

^{b/} Dates of first and second days of the experiment.

^{c/} Daily maximum temperature in °C.²⁹

^{d/} Duration of direct solar radiation reported as percent of possible minutes of sunshine.²⁹

^{e/} Cumulative daily solar radiation expressed in Langley's (cal cm^{-2}); note that the second-day value is the cumulative solar radiation on that day until the experiment was terminated--usually 1700 EST.

^{f/} Time of sunrise in hours (EST); since the times of sunrise are approximately the same for both days, the time is given for the first day only.

^{g/} Daily median concentrations of species tentatively identified to be methyl and ethyl nitrate; they are not listed in the appendix.

^{h/} The initial $[NO_x]$ is taken to be the concentration that existed at approximately the time of sunrise^{k/}; the table entry has NOT been corrected for possible interferences.

^{i/} Fraction of initial NO_x remaining at the 1700 EST hour calculated from NO_x concentrations as determined by^{k/} the chemiluminescent NO_x analyzer.

^{j/} Concentration of accountable test compound at the 1700 EST hour.

^{k/} Estimate of the time at which approximately one-half of the test compound was consumed.

^{l/} Ratio of product sulfur as particulate to the total accountable reacted sulfur at the time of $[SO_2]_{\max}$: $([TPS]/([TPS]+[SO_2]))$.

^{m/} Estimate of ozone half-life based on data collected during the 2000 EST hour of the first day and the 0400 EST hour of the second day: $t_{1/2} \approx 5.543/\ln([O_3]_{2000}/[O_3]_{0400})$.

^{n/} This half-life may be suspect, since ozone concentrations smaller than 0.1 ppm were involved in its determination.

^{o/} Net concentration on the second day is the difference between the second-day maximum concentration and the preceding minimum concentration: $\Delta O_3 = [O_3]_{\max} - [O_3]_{\min}$ and $\Delta SO_2 = [SO_2]_{\max} - [SO_2]_{\min}$.

^{p/} Since SO_2 concentrations were quantifiable for only one measurement in this experiment, this value may not truly represent the maximum concentration.

TABLE 25. SUMMARY OF SELECTED RESULTS FROM SMOG CHAMBER EXPERIMENTS
CONDUCTED WITH $\text{CH}_3\text{SC}_2\text{H}_5$ AND NO_x

TEST COMPOUND ^{a/}	DATE ^{b/}	T_{max} ^{c/}	%SS ^{d/}	CU-SR ^{e/}	SUNRISE ^{f/}
Methyl Ethyl Sulfide	11-9-77	24.4	71	277	6.83
$\text{CH}_3\text{SC}_2\text{H}_5$	11-10-77	23.9	23	105	
SMOG CHAMBER NUMBER		4	3	2	1
FIRST DAY PARAMETERS					
Target Initial HC/ NO_x (ppmC/ppm)		2	4	10	20
Time of NO- NO_2 Crossover, (hrs EST)		8.73	8.63	8.41	8.38
$[\text{NO}_2]_{\text{max}}$, ppm		0.591	0.309	0.121	0.053
Time of $[\text{NO}_2]_{\text{max}}$, (hrs EST)		9.63	9.47	9.80	9.13
$[\text{O}_3]_{\text{max}}$, ppm		0.469	0.335	0.227	0.135
Time of $[\text{O}_3]_{\text{max}}$, (hrs EST)		14.63	11.47	11.30	10.13
$[\text{PAN}]_{\text{max}}$, ppm		ND	ND	ND	ND
Time of $[\text{PAN}]_{\text{max}}$, (hrs EST)		NA	NA	NA	NA
$[\text{MN}]$ ppm ^{g/}		0.008	0.003	ND	tr
$[\text{EN}]$ ppm		0.014	0.018	0.002	0.001
$[\text{NO}_x]_{\text{initial}}^{\text{h/}}$		0.948	0.478	0.203	0.095
$[\text{NO}_x]$ @ 1700 EST		0.177	0.107	0.050	0.032
fNO_x @ 1700 EST ^{i/}		0.187	0.224	0.246	0.337
$[\text{CH}_3\text{SC}_2\text{H}_5]$ @ 1700 EST ^{j/}		tr	tr	0.268	0.332
Time of $[\text{CH}_3\text{SC}_2\text{H}_5]_{\text{h}}$ (hrs EST) ^{k/}		9.52	9.87	10.59	12.77
$[\text{SO}_2]_{\text{max}}$, ppm		tr	tr	tr	tr
Time of $[\text{SO}_2]_{\text{max}}$, (hrs EST)		NA	NA	NA	NA
$[\text{TPS}]_{\text{max}}$, $\mu\text{g}/\text{m}^3$		26.3	20.5	19.3	31.4
(ppmS)		0.020	0.016	0.015	0.024
Time of $[\text{TPS}]_{\text{max}}$, (hrs EST)		10.63	10.47	10.30	10.13
R ^{l/}		ND	ND	ND	ND
$[\text{CN}]_{\text{max}}$, cm^{-3}		24,000	23,000	18,000	18,500
Time of $[\text{CN}]_{\text{max}}$, (hrs EST)		7.63	7.47	7.30	7.13
Night-time O_3 Half-Life (hrs) ^{m/}		14	8	6 ^{n/}	3 ^{n/}

(continued)

NOTES: Abbreviations: ND = no data are available; NA = not applicable;
0 = not detected; tr = detected, but not quantified; X = concentration decreased, no maximum observed.

The appendix should be consulted for additional data that are not summarized in this table.

TABLE 25. (continued)

SHOG CHAMBER NUMBER	4	3	2	1
SECOND DAY PARAMETERS				
$[O_3]_{\max}$, ppm	0.214	0.143	0.091	0.065
ΔO_3 , ppm ^{a/}	0.039	0.069	0.057	0.060
$[SO_2]_{\max}$, ppm	0	tr	0	tr
ΔSO_2 , ppm ^{a/}	NA	NA	NA	NA
$[TPS]_{\max}$, $\mu\text{g}/\text{m}^3$	0	0	0	0
(ppmS)	0	0	0	0
$[CN]_{\max}$, cm^{-3}	1,500	2,100	2,100	14,800

^{a/} Target initial concentration 2.0 ppmC, 0.67 ppm (V/V), or 0.67 ppmS.

^{b/} Dates of first and second days of the experiment.

^{c/} Daily maximum temperature in °C.²⁹

^{d/} Duration of direct solar radiation reported as percent of possible minutes of sunshine.²⁹

^{e/} Cumulative daily solar radiation expressed in Langleys (cal cm^{-2}); note that the second-day value is the cumulative solar radiation on that day until the experiment was terminated--usually 1700 EST.

^{f/} Time of sunrise in hours (EST); since the times of sunrise are approximately the same for both days, the time is given for the first day only.

^{g/} Daily median concentrations of species tentatively identified to be methyl and ethyl nitrate; they are not listed in the appendix.

^{h/} The initial $[NO_x]$ is taken to be the concentration that existed at approximately the time of sunrise^x; the table entry has NOT been corrected for possible interferences.

^{i/} Fraction of initial NO_x remaining at the 1700 EST hour calculated from NO_x concentrations as determined by^x the chemiluminescent NO_x analyzer.

^{j/} Concentration of accountable test compound at the 1700 EST hour.

^{k/} Estimate of the time at which approximately one-half of the test compound was consumed.

^{l/} Ratio of product sulfur as particulate to the total accountable reacted sulfur at the time of $[SO_2]_{\max}$: $([TPS]/([TPS]+[SO_2]))$.

^{m/} Estimate of ozone half-life based on data collected during the 2000 EST hour of the first day and the 0400 EST hour of the second day: $t_{1/2} \approx 5.545/\ln([O_3]_{2000}/[O_3]_{0400})$.

^{n/} This half-life may be suspect, since ozone concentrations smaller than 0.1 ppm were involved in its determination.

^{o/} Net concentration on the second day is the difference between the second-day maximum concentration and the preceding minimum concentration: $\Delta O_3 = [O_3]_{\max} - [O_3]_{\min}$ and $\Delta SO_2 = [SO_2]_{\max} - [SO_2]_{\min}$.

conversion of NO to NO₂ was rapid. Approximately 1.5 hours of irradiation were required to achieve NO-NO₂ crossover on 10 October, and 1.7 hours on 9 November. The maximum NO₂ concentrations occurred during the 0800 EST hour on 10 October and during the 0900 EST hour on 9 November. The duration of irradiation required to achieve NO-NO₂ crossover decreased with increasing initial HC/NO_x ratios. Crossover occurred first at the target HC/NO_x ratio of 20, and conversion occurred more slowly at smaller ratios. In contrast to the propene-NO_x system, however, the time to crossover was not strongly dependent on HC/NO_x ratio.

Ozone accumulated during each experiment. Maximum concentrations and the times required to achieve them were dependent on the initial HC/NO_x ratio. Ozone maxima ranged from 0.14 to 0.43 ppm on 10 October and from 0.14 to 0.47 ppm on 9 November. In both cases a maximum ozone concentration first occurred at the target HC/NO_x ratio of 20 in the morning, one hour after the corresponding maximum NO₂ concentration. Longer times were required at smaller initial HC/NO_x ratios and at the target ratio of 2, maximum ozone concentrations occurred approximately 2 to 3 hours after noon. The largest maximum ozone concentrations, 0.43 and 0.47 ppm, occurred at the target HC/NO_x ratio of 2. Maximum ozone concentrations decreased with increasing initial HC/NO_x ratios (i.e., decreasing initial NO_x concentrations). These reductions in maximum ozone concentrations are also associated with the small reductions in the times to NO-NO₂ crossover noted earlier.

PAN, MN, and EN were found as reaction products. Maximum PAN, as well as median MN and EN concentrations, were dependent on the initial HC/NO_x ratio. The largest concentrations of these species occurred at the target HC/NO_x ratio of 2 and decreased with increasing ratios (i.e., decreasing initial NO_x concentrations). On 10 October the ordering of PAN, MN, and EN concentrations with respect to initial HC/NO_x ratio was similar to that of the maximum ozone concentrations. The tentative identification of EN in addition to the identification of PAN suggests that the photooxidation of methyl ethyl sulfide involves the cleavage of the ethyl-sulfur bond. Although MN may be a reaction product of PAN in the presence of NO_x and air, its tentative identification may also be indicative of a photooxidation step involving the cleavage of the methyl-sulfur bond.

Inspection of the first-day NO_x data in the appendix revealed unusual behavior. At the target HC/NO_x ratio of 20, between 0900 and 1400 EST, the NO_x concentration exhibited a loss of few ppb and a subsequent recovery. The timing of this phenomenon coincided with the initial buildup of PAN. This behavior was not observed at lower HC/NO_x ratios, although it may have been obscured by the higher NO_x concentrations employed in these experiments. It is likely that a transient nitrogen-containing species was responsible for this behavior. This species was either not delivered to the NO_x monitor as a result of interactions with chamber walls or the sampling system, or it could not be detected by the chemiluminescent NO_x monitor that was employed. In any event, the identity of this hypothetical species is unknown.

A nitrogen mass balance was estimated for each experiment based on chemiluminescent NO_x concentrations determined initially and again during the 1700 EST hour of the first day. The nitrogen balances were similar to those for the propene- NO_x , $\text{C}_2\text{H}_5\text{SH}-\text{NO}_x$, $(\text{C}_2\text{H}_5\text{S})_2-\text{NO}_x$, and $\text{C}_2\text{H}_5\text{SC}_2\text{H}_5-\text{NO}_x$ experiments. The fraction of initial NO_x that could be accounted for in the 10 October experiments ranged from 0.22 to 0.40 and in the 9 November experiments, 0.19 to 0.34. The accountable fraction increased with increasing initial HC/NO_x ratios (i.e., decreasing initial NO_x concentrations). The unaccountable product nitrogen may be nitric acid or other undetermined nitrogen-containing species. The fate of NO_x in photochemically reacting systems is largely unknown.

The test species, $\text{CH}_3\text{SC}_2\text{H}_5$, was consumed rapidly during these experiments. Since in most cases only trace amounts of SO_2 were detected, the $\text{CH}_3\text{SC}_2\text{H}_5$ concentration could be approximated by the total sulfur concentration. Estimates were made of the concentrations of $\text{CH}_3\text{SC}_2\text{H}_5$ that remained unreacted at the 1700 EST hour of the first day. The ordering of the concentrations of remaining $\text{CH}_3\text{SC}_2\text{H}_5$ was similar to that observed earlier for the fraction of NO_x that remained at the 1700 EST hour. In both cases the fractions of unreacted reactants increased with increasing initial HC/NO_x ratios. On 10 October the concentrations of remaining $\text{CH}_3\text{SC}_2\text{H}_5$ ranged from a trace to 0.41 ppmS and on 9 November, from a trace to 0.33 ppmS. Inspection of the times to one-half consumption of $\text{CH}_3\text{SC}_2\text{H}_5$ also indicates that the $\text{CH}_3\text{SC}_2\text{H}_5$ disappearance rate was dependent on the initial HC/NO_x ratio--increasing with decreasing ratios.

Sulfur dioxide was found as a product of the photooxidation of $\text{CH}_3\text{SC}_2\text{H}_5$ in the presence of NO_x , although in 2 of the 10 October experiments and in all of the 9 November experiments only trace quantities were detected. In the 10 October results, sulfur dioxide maximum concentrations appear to depend on the initial HC/NO_x ratio. On this day $[\text{SO}_2]_{\text{max}}$ values ranged from a trace to 0.08 ppm. Maximum concentrations were quantified at target HC/NO_x ratios of 2 and 4, and were achieved during the 0900 EST hour. The largest $[\text{SO}_2]_{\text{max}}$ was 0.08 ppm and occurred at the target HC/NO_x ratio of 2. Maximum SO_2 concentrations on 10 October appeared to decrease with increasing in HC/NO_x ratios and exhibited behavior similar to that observed earlier for another reaction product, ozone.

Moderate quantities of condensation nuclei were produced on the first day. Maximum concentrations generally occurred early in the day ranging from 22,000 to 31,000 cm^{-3} during the 1000 EST hour on 10 October and from 18,000 to 24,000 cm^{-3} during the 0700 EST hour on 9 November. Maximum concentrations of condensation nuclei displayed no apparent trends with initial HC/NO_x ratio.

Conversion of $\text{CH}_3\text{SC}_2\text{H}_5$ to particulate sulfur was rapid, and maximum TPS concentrations were dependent on the initial HC/NO_x ratio. Maximum TPS concentrations were achieved during the 0900 EST hour on 10 October and during the 1000 EST hour on 9 November. Only a small portion of the reacted test species was detected as particulate sulfur, although the fraction was higher on 10 October than 9 November. On 10 October maximum TPS concentrations ranged from 32 to 142 $\mu\text{g}/\text{m}^3$, the equivalent of 0.02 to 0.11 ppmS, and decreased with increasing initial HC/NO_x ratios (i.e., decreasing initial NO_x concentrations). On this date the largest $[\text{TPS}]_{\text{max}}$, 142 $\mu\text{g}/\text{m}^3$, occurred at the target HC/NO_x ratio of 2. On 9 November maximum TPS concentrations were significantly smaller than the corresponding values observed on 10 October, and ranged from 20 to 31 $\mu\text{g}/\text{m}^3$. Although maximum TPS concentrations decreased with increasing HC/NO_x ratios with only a single exception, the narrow spread among the maximum concentrations obscures the generality of this finding. The reduced light intensity on 9 November may have contributed to the reduced TPS concentrations observed on 9 November in comparison to those on 10 October.

The ratio of product sulfur as particulate to the total accountable reacted sulfur ([TPS] plus [SO₂]) was determined for each experiment. This ratio was based on data collected during the hour of occurrence of the maximum SO₂ concentration, and it permits an assessment of the distribution of accountable product sulfur between the gas and particulate phases. Data were available to permit an assessment of this ratio in none of the 9 November experiments and in only 2 of the 4 experiments conducted on 10 October. These results, 0.53 and 0.58, suggest that for at least two CH₃SC₂H₅-NO_x experiments almost 60 percent of the accountable product sulfur existed as particulate. In addition, results in the appendix indicate that a substantial portion of the product sulfur cannot be accounted for.

Second-day solar radiation was reduced in comparison to the first-day values on both 11 October and 10 November, although the reduction was not as large for the October experiment as for the November experiment. Only trace quantities of SO₂ were detected on the second day, and concentrations of TPS, CN, and O₃ were generally less than the corresponding first-day levels. As seen in Tables 24 and 25, TPS was not detected on 11 October or on 10 November. Second-day maximum CN concentrations were low in both cases, exceeding 3000 cm⁻³ only once and displaying no apparent trends with initial conditions. On 11 October second-day ozone maxima approached but did not exceed the corresponding first-day maxima, although the ordering with respect to initial conditions was the same on both days. In addition, net ozone concentrations ranged from 0.13 to 0.19 ppm and generally decreased with increasing initial HC/NO_x ratios. On 10 November second-day ozone maxima did not exceed first-day maxima, and the ordering with respect to initial conditions was the same on both days. The net concentrations ranged from 0.04 to 0.07 ppm and displayed no apparent trends with initial conditions. Moreover, the small net ozone concentrations indicate that little ozone was generated under the cloudy conditions that prevailed on 10 November.

Ethanethiol

Mixtures of ethanethiol and NO_x were irradiated in Chamber Nos. 2 and 4 on 26 and 27 August and in all four chambers on 3 and 4 October 1977. On 26 August the cumulative daily solar radiation was 417 cal cm⁻² with 55 percent

of the possible minutes of direct sunshine and a maximum temperature of 28.9° C. On 3 October the cumulative daily solar radiation was 395 cal cm⁻² with 73 percent of the possible minutes of direct sunshine and a maximum temperature of 18.3° C. Selected results from the C₂H₅SH-NO_x experiments are summarized in Tables 26 and 27. In general, only the October experiments are considered in the current discussion. Concentration-time profiles of various reactants and products for the 3 October experiment conducted in Chamber No. 4 are presented in Figure 20.

The photochemical behavior of irradiated mixtures of NO_x and C₂H₅SH was similar in many respects to that of irradiated mixtures of NO_x and hydrocarbons such as propene. In each of the C₂H₅SH-NO_x experiments conversion of NO to NO₂ was rapid. Approximately 1.4 hours were required to achieve NO-NO₂ crossover with the maximum NO₂ concentration occurring during the 0700 and 0800 EST hours. Among the four experiments, NO-NO₂ crossover occurred first at the target HC/NO_x ratio of 4, and slightly longer times were required as the target HC/NO_x ratios were moved away from 4. In contrast to the propene-NO_x system, however, the time to crossover was not strongly dependent on the target HC/NO_x ratio.

Ozone accumulated during each experiment. Maximum concentrations were dependent on the initial HC/NO_x ratio. Ozone maxima occurred during the 1500 EST hour and ranged from 0.08 to 0.36 ppm. The largest [O₃]_{max}, 0.36 ppm, occurred at the target HC/NO_x ratio of 4. As the target HC/NO_x ratio was moved away from 4, maximum ozone concentrations decreased. These reductions in maximum ozone concentrations are also associated with the small increases in the times to NO-NO₂ crossover noted earlier.

For these experiments, PAN as well as MN and EN concentration data were erratic, and as a result are reported in Table 27 but not in the appendix. Maximum PAN and median MN and EN concentrations were dependent on the initial HC/NO_x ratio. The concentrations of both MN and EN increased with decreasing HC/NO_x ratios (i.e. with increasing initial NO_x concentrations). In contrast, the ordering of the maximum PAN concentrations with respect to initial HC/NO_x ratio was similar to that of the maximum ozone concentrations. The largest maximum PAN concentration for the four experiments occurred at the target HC/NO_x ratio of 4. PAN maxima generally occurred between the 1400

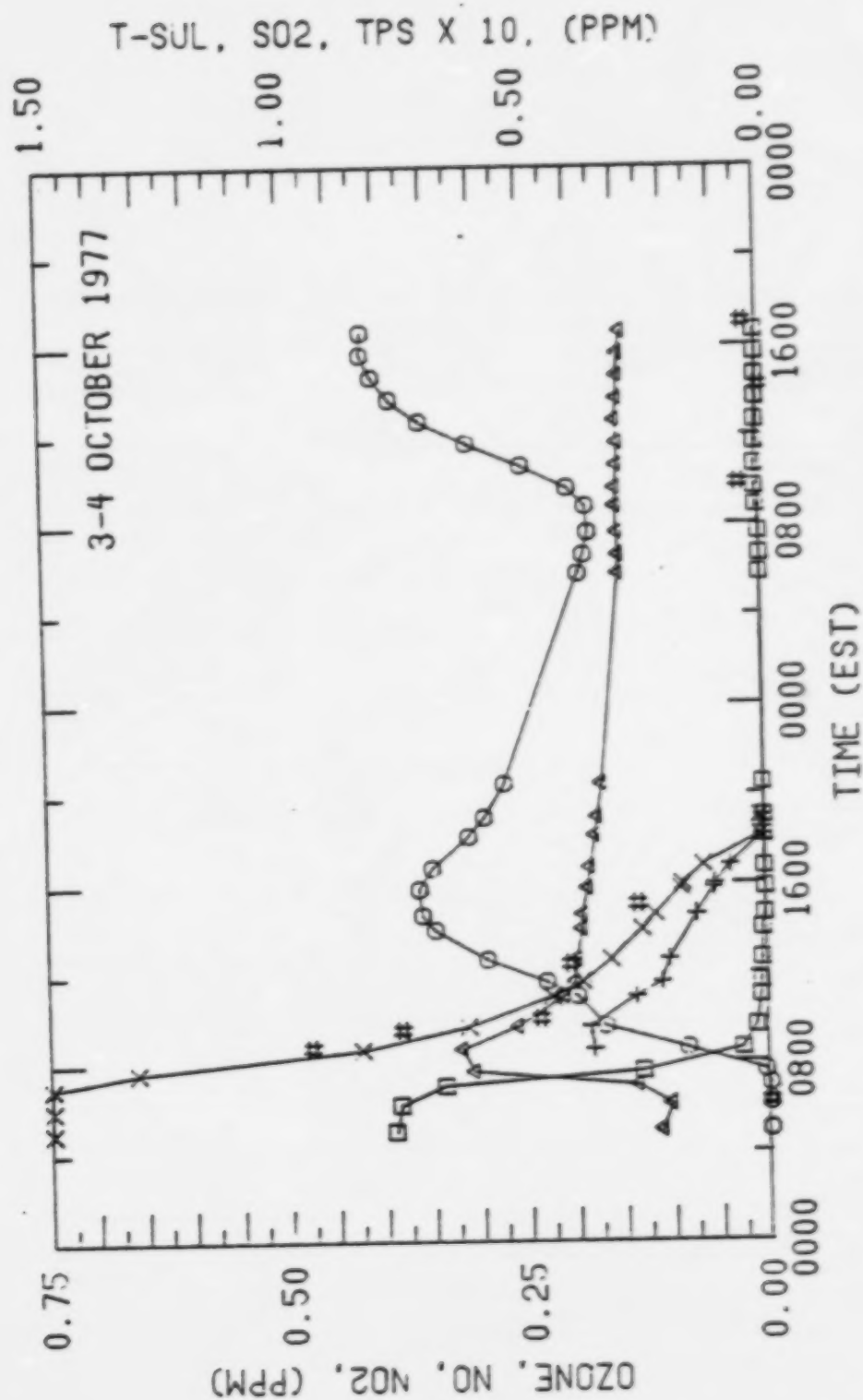


Figure 20. Concentration-time profiles of various reactants and products for the 3 and 4 October 1977 $C_2H_5SH-NO_x$ experiment conducted in RTI Chamber No. 4. Target initial conditions: 2.0 ppm C_2H_5SH and 0.5 ppm NO_x . Symbol key: (o) O_3 ; (□) NO ; (Δ) NO_2 ; (x) Total Sulfur; (+) SO_2 ; and (#) TPS.

TABLE 26. SUMMARY OF SELECTED RESULTS FROM SMOG CHAMBER EXPERIMENTS
CONDUCTED WITH C_2H_5SH AND NO_x

TEST COMPOUND ^{a/}	DATE ^{b/}	T _{max} ^{c/}	%SS ^{d/}	CU-SR ^{e/}	SUNRISE ^{f/}
Ethanethiol	8-26-77	28.9	55	417	5.65
C_2H_5SH	8-27-77	30.0	49	404	
SMOG CHAMBER NUMBER			2	4	
FIRST DAY PARAMETERS					
Target Initial HC/NO_x (ppmC/ppm)			10	10	
Time of $NO-NO_2$ Crossover, (hrs EST)			7.46	7.42	
$[NO_2]_{max}$, ppm			0.477	0.425	
Time of $[NO_2]_{max}$, (hrs EST)			8.30	8.63	
$[O_3]_{max}$, ppm			0.556	0.548	
Time of $[O_3]_{max}$, (hrs EST)			15.30	15.63	
$[PAN]_{max}$, ppm			0.132	0.125	
Time of $[PAN]_{max}$, (hrs EST)			11.30	12.63	
$[HN]_{ppm}$ ^{g/}			0.010	0.010	
$[EN]_{ppm}$			ND	ND	
$[NO_x]_{initial}$ ^{h/}			0.635	0.636	
$[NO_x]$ @ 1700 EST			0.169	0.175	
ENO_x @ 1700 EST ^{i/}			0.266	0.275	
$[C_2H_5SH]$ @ 1700 EST ^{j/}			ND	ND	
Time of $[C_2H_5SH]_{k/}$ (hrs EST)			ND	ND	
$[SO_2]_{max}$, ppm			ND	ND	
Time of $[SO_2]_{max}$, (hrs EST)			NA	NA	
$[TPS]_{max}$, $\mu g/m^3$			76.0	103.0	
(ppmS)			0.058	0.079	
Time of $[TPS]_{max}$, (hrs EST)			11.30	10.63	
R ^{l/}			ND	ND	
$[CH]_{max}$, cm^{-3}			135,000	185,000	
Time of $[CH]_{max}$, (hrs EST)			19.30	20.63	
Night-time O_3 Half-life (hrs) ^{m/}			8	9	

(continued)

NOTES: Abbreviations: ND = no data are available; NA = not applicable;
0 = not detected; tr = detected, but not quantified; X = concentration decreased, no maximum observed.

The appendix should be consulted for additional data that are not summarized in this table.

TABLE 26. (continued)

SMOG CHAMBER NUMBER	2	4
SECOND DAY PARAMETERS		
$[O_3]_{\max}$, ppm	0.649	0.634
ΔO_3 , ppm ^{a/}	0.508	0.483
$[SO_2]_{\max}$, ppm	ND	ND
ΔSO_2 , ppm ^{a/}	NA	NA
$[TPS]_{\max}$, $\mu g/m^3$ ^{R/}	0	0
(ppmS) ^{R/}	0	0
$[CN]_{\max}$, cm ⁻³	107,000	112,000

^{a/} Target initial concentration 3.0 ppmC, 2.5 ppm (V/V), or 2.5 ppmS.

^{b/} Dates of first and second days of the experiment.

^{c/} Daily maximum temperature in °C.²⁹

^{d/} Duration of direct solar radiation reported as percent of possible minutes of sunshine.²⁹

^{e/} Cumulative daily solar radiation expressed in Langley (cal cm⁻²); note that the second-day value is the cumulative solar radiation on that day until the experiment was terminated--usually 1700 EST.

^{f/} Time of sunrise in hours (EST); since the times of sunrise are approximately the same for both days, the time is given for the first day only.

^{g/} Daily median concentrations of species tentatively identified to be methyl and ethyl nitrate; they are not listed in the appendix.

^{h/} The initial $[NO_x]$ is taken to be the concentration that existed at approximately the time of sunrise^x; the table entry has NOT been corrected for possible interferences.

^{i/} Fraction of initial NO_x remaining at the 1700 EST hour calculated from NO_x concentrations as determined by^x the chemiluminescent NO_x analyzer.

^{j/} Concentration of accountable test compound at the 1700 EST hour.

^{k/} Estimate of the time at which approximately one-half of the test compound was consumed.

^{l/} Ratio of product sulfur as particulate to the total accountable reacted sulfur at the time of $[SO_2]_{\max}$: $(([TPS])/([TPS] + [SO_2]))$.

^{m/} Estimate of ozone half-life based on data collected during the 2000 EST hour of the first day and the 0400 EST hour of the second day: $t_{1/2} \cong 5.545/\ln ([O_3]_{2000}/[O_3]_{0400})$.

^{n/} This half-life may be suspect, since ozone concentrations smaller than 0.1 ppm were involved in its determination.

^{o/} Net concentration on the second day is the difference between the second-day maximum concentration and the preceding minimum concentration: $\Delta O_3 = [O_3]_{\max} - [O_3]_{\min}$ and $\Delta SO_2 = [SO_2]_{\max} - [SO_2]_{\min}$.

^{p/} Since second-day [TPS] were determined only once for each chamber, these data do not truly represent maximum values.

TABLE 27. SUMMARY OF SELECTED RESULTS FROM SMOG CHAMBER EXPERIMENTS
CONDUCTED WITH C₂H₅SH AND NO_x

TEST COMPOUND ^{a/}	DATE ^{b/}	T _{max} ^{c/}	%SS ^{d/}	CU-SR ^{e/}	SUNRISE ^{f/}
Ethanethiol	10-3-77	18.3	73	395	6.10
C ₂ H ₅ SH	10-4-77	19.4	76	423	
SMOG CHAMBER NUMBER		3	4	1	2
FIRST DAY PARAMETERS				10	20
Target Initial HC/NO _x (ppmC/ppm)		2	4		
Time of NO-NO ₂ Crossover, (hrs EST)		7.44	7.32	7.54	7.70
[NO ₂] _{max} , ppm		0.611	0.322	0.088	0.040
Time of [NO ₂] _{max} , (hrs EST)		8.47	8.63	8.13	7.30
[O ₃] _{max} , ppm		0.313	0.364	0.142	0.080
Time of [O ₃] _{max} , (hrs EST)		15.47	15.80	15.63	15.30
[PAN] _{max} , ppm ^{g/}		0.104	0.124	0.051	0.024
Time of [PAN] _{max} , (hrs EST) ^{g/}		14.47	15.80	16.13	14.30
[MN] ppm ^{h/}		0.035	0.009	tr	0
[EN] ppm		0.037	0.009	0.006	0.003
[NO _x] _{initial} ^{h/}		0.948	0.491	0.179	0.086
[NO _x] @ 1700 EST		0.220	0.184	0.069	0.035
fNO _x @ 1700 EST ^{i/}		0.232	0.375	0.385	0.407
[C ₂ H ₅ SH] @ 1700 EST ^{i/}		0.043	0.054	0.357	0.537
Time of [C ₂ H ₅ SH] _{1/2} , (hrs EST) ^{k/}		8.06	8.19	8.49	11.64
[SO ₂] _{max} , ppm		0.366	0.374	0.280	0.160
Time of [SO ₂] _{max} , (hrs EST)		9.47	9.63	9.13	10.30
[TPS] _{max} , µg/m ³		141.5	125.0	68.4	48.2
(ppmS)		0.109	0.096	0.052	0.037
Time of [TPS] _{max} , (hrs EST)		8.47	8.63	9.13	9.30
R ^{l/}		0.18	0.17	0.16	0.13
[CN] _{max} , cm ⁻³		39,000	42,000	41,000	39,000
Time of [CN] _{max} , (hrs EST)		8.37	9.63	8.13	9.30
Night-time O ₃ Half-Life (hrs) ^{m/}		14	18	4 ^{n/}	ND ^{n/}

(continued)

NOTES: Abbreviations: ND = no data are available; NA = not applicable;
0 = not detected; tr = detected, but not quantified; X = concentration decreased, no maximum observed.

The appendix should be consulted for additional data that are not summarized in this table.

TABLE 27. (continued)

SMOG CHAMBER NUMBER	3	4	1	2
SECOND DAY PARAMETERS				
$[O_3]_{max}$, ppm	0.442	0.414	0.171	0.112
ΔO_3 , ppm ^{a/}	0.323	0.235	0.165	0.112
$[SO_2]_{max}$, ppm	ND	ND	ND	ND
ΔSO_2 , ppm ^{a/}	NA	NA	NA	NA
$[TPS]_{max}$, $\mu g/m^3$	4.9	5.7	5.8	5.0
(ppmS)	0.004	0.004	0.004	0.004
$[CN]_{max}$, cm^{-3}	6,300	5,700	14,500	17,500

^{a/} Target initial concentration 2.0 ppmC, 1.0 ppm (V/V), or 1.0 ppmS.

^{b/} Dates of first and second days of the experiment.

^{c/} Daily maximum temperature in °C.²⁹

^{d/} Duration of direct solar radiation reported as percent of possible minutes of sunshine.²⁹

^{e/} Cumulative daily solar radiation expressed in Langleys ($cal\ cm^{-2}$); note that the second-day value is the cumulative solar radiation on that day until the experiment was terminated--usually 1700 EST.

^{f/} Time of sunrise in hours (EST); since the times of sunrise are approximately the same for both days, the time is given for the first day only.

^{g/} Daily median concentrations of species tentatively identified to be methyl and ethyl nitrate; they are not listed in the appendix.

^{h/} The initial $[NO_x]$ is taken to be the concentration that existed at approximately the time of sunrise^x; the table entry has NOT been corrected for possible interferences.

^{i/} Fraction of initial NO_x remaining at the 1700 EST hour calculated from NO_x concentrations as determined by^x the chemiluminescent NO_x analyzer.

^{j/} Concentration of accountable test compound at the 1700 EST hour.

^{k/} Estimate of the time at which approximately one-half of the test compound was consumed.

^{l/} Ratio of product sulfur as particulate to the total accountable reacted sulfur at the time of $[SO_2]_{max}$: $([TPS]/([TPS]+[SO_2]))$.

^{m/} Estimate of ozone half-life based on data collected during the 2000 EST hour of the first day and the 0400 EST hour of the second day: $t_{1/2} \approx 5.545/\ln ([O_3]_{2000}/[O_3]_{0400})$.

^{n/} This half-life may be suspect, since ozone concentrations smaller than 0.1 ppm were involved in its determination.

^{o/} Net concentration on the second day is the difference between the second-day maximum concentration and the preceding minimum concentration: $\Delta O_3 = [O_3]_{max} - [O_3]_{min}$ and $\Delta SO_2 = [SO_2]_{max} - [SO_2]_{min}$.

^{p/} PAN data erratic; only maximum concentration reported; data are not listed in the Appendix.

and 1600 EST hours. The tentative identification of MN and EN in addition to the identification of PAN suggests that the photooxidation of ethanethiol involves the cleavage of the ethyl-sulfur bond, which in the presence of air and NO_x leads to the formation of MN, EN, and PAN.

Inspection of the first-day NO_x data in the appendix revealed unusual behavior. At the target HC/NO_x ratio of 20, between 0800 and 1100 EST, the NO_x concentration exhibited a loss of a few ppb and a subsequent partial recovery. This behavior was not observed in the remaining three experiments, although it may have been obscured by the higher NO_x concentrations employed in these experiments. It is likely that a transient nitrogen-containing species was responsible for this behavior. This species was either not delivered to the NO_x monitor as a result of interactions with chamber walls or the sampling system, or it could not be detected by the chemiluminescent NO_x monitor that was employed. At any rate, the identity of this hypothetical species is unknown.

A nitrogen mass balance was estimated for each experiment based on chemiluminescent NO_x concentrations determined initially and again during the 1700 EST hour of the first day. The nitrogen balances were similar to those for the propene- NO_x experiments and much better than for the $\text{CH}_3\text{SH}-\text{NO}_x$ experiments. For the four $\text{C}_2\text{H}_5\text{SH}-\text{NO}_x$ experiments the fraction of initial NO_x that could be accounted for ranged from 0.23 to 0.41. This fraction generally increased with increasing initial HC/NO_x ratios (i.e., decreasing initial NO_x concentrations). The unaccountable product nitrogen may be nitric acid or other undetermined nitrogen-containing species. The fate of NO_x in photochemically reacting systems is largely unknown.

Initially the total sulfur concentration exceeded the linear range of the sulfur instrument. The test species, $\text{C}_2\text{H}_5\text{SH}$, was consumed rapidly during these experiments, and within a few hours after sunrise its concentration could be approximated by the difference between the total sulfur and the SO_2 concentrations. Estimates were made of the concentrations of $\text{C}_2\text{H}_5\text{SH}$ that remained unreacted at the 1700 EST hour of the first day. The ordering of the concentrations of remaining $\text{C}_2\text{H}_5\text{SH}$ was similar to that observed earlier for the fraction of remaining NO_x . In both cases the fractions of unreacted reactants increased with increasing initial HC/NO_x ratios. For

the four experiments the concentrations of remaining C_2H_5SH ranged from 0.04 to 0.54 ppmS. At the initial target HC/NO_x ratio of 2, the smallest amount of C_2H_5SH could be accounted for at 1700, although it was not significantly smaller than the corresponding value at the target ratio of 4. Inspection of the times to one-half consumption of C_2H_5SH also indicates that the C_2H_5SH disappearance rate was dependent on the initial HC/NO_x ratio--increasing with decreasing ratios.

In each of the four experiments sulfur dioxide was found as a product of the photooxidation of C_2H_5SH in the presence of NO_x . Maximum concentrations were dependent on the initial HC/NO_x ratio. Sulfur dioxide maxima ranged from 0.16 to 0.37 ppm and with one exception occurred during the 0900 EST hour. The largest $[SO_2]_{max}$ was 0.374 ppm and was achieved at the target initial HC/NO_x ratio of 4, although it was not significantly larger than the corresponding maximum value of 0.366 ppm that was achieved at the target ratio of 2. The apparent relationship between $[SO_2]_{max}$ and initial HC/NO_x ratio was similar to that observed earlier for another reaction product, ozone. In both cases the largest maximum concentrations occurred at the target initial HC/NO_x ratio of 4 and decreased as the initial HC/NO_x ratios were moved away from 4.

Moderate quantities of condensation nuclei were produced on the first day. Maximum concentrations generally occurred early, before 1000 EST. They were not appreciably different for the four experiments, ranging from 39,000 to 42,000 cm^{-3} . Although the largest $[CN]_{max}$ occurred at the target HC/NO_x ratio of 4, the narrow spread among the maximum concentrations prevented a meaningful evaluation of trends with respect to the various initial conditions. Comparison of the 26 August CN data for the $C_2H_5SH-NO_x$ experiments with those of the CH_3SH-NO_x experiments indicated comparable concentrations of CN with diameters greater than 0.26 μm . However, the C_2H_5SH experiments produced large numbers of CN with diameters between 0.002 and 0.26 μm that were not found in the experiments conducted with CH_3SH .

Conversion of C_2H_5SH to particulate sulfur was rapid, and maximum $[TPS]_{max}$ concentrations were dependent on the initial HC/NO_x ratio. Maximum $[TPS]_{max}$ concentrations were achieved before 1000 EST. Only a small portion of the reacted test species was detected as particulate sulfur, with maximum concentrations ranging from 48 to 142 $\mu g/m^3$ or the equivalent of 0.04 to 0.11

ppmS. Maximum TPS concentrations decreased with increasing initial HC/NO_x ratios (i.e., decreasing initial NO_x concentrations). The largest [TPS]_{max}, 142 µg/m³, occurred at the target HC/NO_x ratio of 2.

The ratio of product sulfur as particulate to the total accountable reacted sulfur [(TPS) plus (SO₂)] was determined for each experiment. This ratio was based on data collected during or interpolated for the hour of occurrence of the maximum SO₂ concentration, and it permits an assessment of the distribution of accountable product sulfur between the gas and particulate phases. For the C₂H₅SH-NO_x system, this ratio was small, ranging from 0.13 to 0.18, and it decreased with increasing initial HC/NO_x ratios (i.e., decreasing initial NO_x concentrations). Thus, most of the accountable product sulfur existed as SO₂ in the C₂H₅SH-NO_x system, and SO₂ comprised increasing proportions with increasing initial HC/NO_x ratios. In addition, results in the appendix suggest that a substantial portion of the product sulfur cannot be accounted for.

Second-day maximum TPS concentrations were low, accounting for 4.9 to 5.8 µg/m³ or approximately 0.004 ppmS. Although SO₂ data were not available on the second day, significant quantities of both CN and ozone were measured. Second-day CN maxima were less than the corresponding first day maxima and ranged from 5700 to 17500 cm⁻³. They also generally increased with increasing initial HC/NO_x ratios. Second-day maximum ozone concentrations exceeded first-day maxima. Net ozone concentrations ranged from 0.11 to 0.32 ppm and exceeded the first-day maxima in three of four cases. Second-day maximum as well as net ozone concentrations decreased with increasing initial HC/NO_x ratios (i.e., decreasing initial NO_x concentrations). The largest net ozone concentration, 0.32 ppm, was achieved at the target HC/NO_x ratio of 2, the experiment that had had the largest initial NO_x concentration and the largest absolute concentration of NO_x remaining at the 1700 EST hour of the first day.

Ethyl Sulfide

Mixtures of ethyl sulfide and NO_x were irradiated on 15 and 16 October 1977. On 15 October the cumulative daily solar radiation was 404 cal cm⁻² with 100 percent of the possible minutes of direct sunshine and a maximum

temperature of 20.0° C. Selected results from the $C_2H_5SC_2H_5-NO_x$ experiments are summarized in Table 28. Concentration-time profiles of various reactants and products for the experiment conducted in Chamber No. 2 are presented in Figure 21.

The photochemical behavior of irradiated mixtures of NO_x and $C_2H_5SC_2H_5$ was similar in many respects to that of irradiated mixtures of NO_x and hydrocarbons such as propene. In each of the $C_2H_5SC_2H_5-NO_x$ experiments conversion of NO to NO_2 was rapid. Approximately 1.7 hours of irradiation were required to achieve NO- NO_2 crossover, and in three of four cases the maximum NO_2 concentrations occurred before 1000 EST. Among the four experiments, NO- NO_2 crossover was first achieved at the target HC/ NO_x ratio of 10, and slightly longer times were required as the ratios were moved away from 10. In contrast to the propene- NO_x system, the time to crossover was not strongly dependent on the initial HC/ NO_x ratio.

Ozone accumulated during each experiment. Maximum concentrations and the times required to achieve them were dependent on the initial HC/ NO_x ratio. Ozone maxima ranged from 0.16 to 0.48 ppm. A maximum ozone concentration occurred first at the target HC/ NO_x ratio of 10 during the 1000 EST hour, and longer times were required as the target HC/ NO_x ratios were moved away from 10. The largest $[O_3]_{max}$, 0.48 ppm, occurred at the target HC/ NO_x ratio of 2. Maximum ozone concentrations decreased with increasing initial HC/ NO_x ratios (i.e., decreasing initial NO_x concentrations).

PAN, MN, and EN were found as reaction products. Maximum PAN concentrations occurred during the 1200 EST hour at the target HC/ NO_x ratios of 4 and 10; they occurred several hours earlier at ratios of 2 and 20. Maximum PAN as well as median MN and EN concentrations were dependent on the initial HC/ NO_x ratio. The largest concentrations of these species occurred at the target HC/ NO_x ratio of 2 and decreased with increasing ratios (i.e., decreasing initial NO_x concentrations). For the four experiments the ordering of PAN, MN, and EN concentrations with respect to initial HC/ NO_x ratio was similar to that of the maximum ozone concentrations. In addition, the ordering of MN and EN with respect to initial HC/ NO_x ratio was similar to that observed for the ethanethiol experiments. The tentative identification of MN and EN in addition to the identification of PAN suggests that the photooxidation of ethyl sulfide involves the cleavage of the ethyl-sulfur

TABLE 28. SUMMARY OF SELECTED RESULTS FROM SMOG CHAMBER EXPERIMENTS
CONDUCTED WITH $C_2H_5SC_2H_5$ AND NO_x

TEST COMPOUND ^{a/}	DATE ^{b/}	T_{max} ^{c/}	%SS ^{d/}	CU-SR ^{e/}	SUNRISE ^{f/}
Ethyl Sulfide	10-15-77	20.0	100	404	6.33
$C_2H_5SC_2H_5$	10-16-77	12.8	17	149	
SMOG CHAMBER NUMBER		2	1	4	3
FIRST DAY PARAMETERS					
Target Initial HC/ NO_x (ppmC/ppm)		2	4	10	20
Time of NO- NO_2 Crossover, (hrs EST)		8.27	8.07	7.87	7.91
$[NO_2]_{max}$, ppm		0.619	0.317	0.119	0.055
Time of $[NO_2]_{max}$, (hrs EST)		9.30	9.13	8.30	15.47
$[O_3]_{max}$, ppm		0.484	0.337	0.231	0.162
Time of $[O_3]_{max}$, (hrs EST)		15.30	14.13	10.63	15.47
$[PAN]_{max}$, ppm		0.119	0.078	0.048	0.033
Time of $[PAN]_{max}$, (hrs EST)		14.30	12.13	12.63	16.47
$[MN]$ ppm ^{g/}		0.008	0.002	0	0
$[EN]$ ppm		0.018	0.006	0.003	0.002
$[NO_x]_{initial}$ ^{h/}		1.021	0.522	0.208	0.107
$[NO_x]$ @ 1700 EST		0.255	0.167	0.085	0.065
fNO_x @ 1700 EST ^{i/}		0.250	0.320	0.409	0.607
$[C_2H_5SC_2H_5]$ @ 1700 EST ^{j/}		0.016	0.041	0.189	0.307
Time of $[C_2H_5SC_2H_5]_{1/2}$ (hrs EST) ^{k/}		9.31	9.54	10.29	12.93
$[SO_2]_{max}$, ppm		0.118	tr	tr	tr
Time of $[SO_2]_{max}$, (hrs EST)		11.30	NA	NA	NA
$[TPS]_{max}$, $\mu g/m^3$		61.4	63.5	25.2	24.4
(ppmS)		0.047	0.049	0.019	0.019
Time of $[TPS]_{max}$, (hrs EST)		9.30	9.13	9.63	9.47
R ^{l/}		0.16	ND	ND	ND
$[CN]_{max}$, cm^{-3}		58,000	27,000	17,500	16,000
Time of $[CN]_{max}$, (hrs EST)		16.30	8.47	8.30	8.13
Night-time O_3 Half-Life (hrs) ^{m/}		15	8	7 ^{n/}	7 ^{n/}

(continued)

NOTES: Abbreviations: ND = no data are available; NA = not applicable;
0 = not detected; tr = detected, but not quantified; X = concentration decreased, no maximum observed.

The appendix should be consulted for additional data that are not summarized in this table.

TABLE 28. (continued)

SMOG CHAMBER NUMBER	2	1	4	3
SECOND DAY PARAMETERS				
$[O_3]_{\max}$, ppm	0.200	0.084	0.064	0.037
ΔO_3 , ppm ^{a/}	0.002	0.010	0.017	0.037
$[SO_2]_{\max}$, ppm	0	0	0	0
ΔSO_2 , ppm ^{a/}	NA	NA	NA	NA
$[TPS]_{\max}$, $\mu\text{g}/\text{m}^3$	2.3	0	3.4	0
(ppmS)	0.002	0	0.003	0
$[CN]_{\max}$, cm^{-3}	250	250	210	250

^{a/} Target initial concentration 2.0 ppmC, 0.50 ppm (V/V), or 0.50 ppmS.

^{b/} Dates of first and second days of the experiment.

^{c/} Daily maximum temperature in °C.²⁹

^{d/} Duration of direct solar radiation reported as percent of possible minutes of sunshine.²⁹

^{e/} Cumulative daily solar radiation expressed in Langley (cal cm⁻²); note that the second-day value is the cumulative solar radiation on that day until the experiment was terminated--usually 1700 EST.

^{f/} Time of sunrise in hours (EST); since the times of sunrise are approximately the same for both days, the time is given for the first day only.

^{g/} Daily median concentrations of species tentatively identified to be methyl and ethyl nitrate; they are not listed in the appendix.

^{h/} The initial $[NO_x]$ is taken to be the concentration that existed at approximately the time of sunrise^x; the table entry has NOT been corrected for possible interferences.

^{i/} Fraction of initial NO_x remaining at the 1700 EST hour calculated from NO_x concentrations as determined by^x the chemiluminescent NO_x analyzer.

^{j/} Concentration of accountable test compound at the 1700 EST hour.

^{k/} Estimate of the time at which approximately one-half of the test compound was consumed.

^{l/} Ratio of product sulfur as particulate to the total accountable reacted sulfur at the time of $[SO_2]_{\max}$: $([TPS]/([TPS]+[SO_2]))$.

^{m/} Estimate of ozone half-life based on data collected during the 2000 EST hour of the first day and the 0400 EST hour of the second day: $t_{1/2} \cong 5.545/\ln ([O_3]_{2000}/[O_3]_{0400})$.

^{n/} This half-life may be suspect, since ozone concentrations smaller than 0.1 ppm were involved in its determination.

^{o/} Net concentration on the second day is the difference between the second-day maximum concentration and the preceding minimum concentration: $\Delta O_3 = [O_3]_{\max} - [O_3]_{\min}$ and $\Delta SO_2 = [SO_2]_{\max} - [SO_2]_{\min}$.

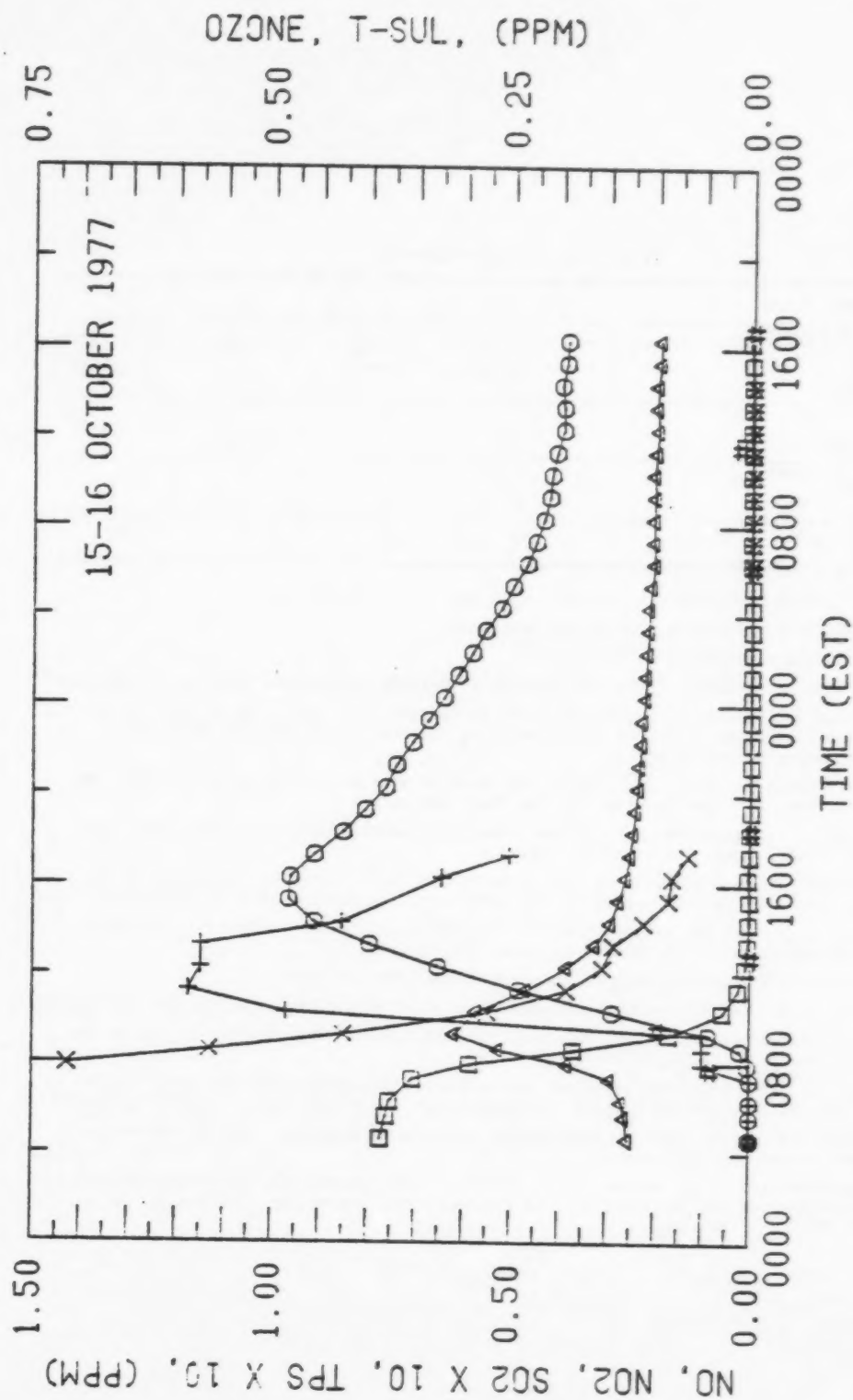


Figure 21. Concentration-time profiles of various reactants and products for the 15 and 16 October 1977 $C_2H_5SC_2H_5-NO_x$ experiment conducted in RTI Chamber No. 2. Target initial conditions: 2.0 ppmC $C_2H_5SC_2H_5$ and 1.0 ppm NO_x . Symbol key: (o) O_3 ; (□) NO; (Δ) NO_2 ; (x) Total Sulfur; (+) SO_2 ; and (##) TPS.

bond, which in the presence of air and NO_x leads to the formation of MN, EN, and PAN.

Inspection of the first-day NO_x data in the appendix revealed unusual behavior. At the two highest initial HC/ NO_x ratios between 0900 and 1200 EST, the NO_x concentration exhibited a loss of approximately 10 ppb and a subsequent recovery. The timing of this phenomenon coincided with the initial buildup of PAN. This behavior was not observed in the remaining two experiments, although it may have been obscured by the higher NO_x concentrations employed in these experiments. It is likely that a transient nitrogen-containing species was responsible for this behavior. This species was either not delivered to the NO_x monitor as a result of interactions with chamber walls or the sampling system, or it could not be detected by the chemiluminescent NO_x monitor that was employed. At any rate, the identity of this hypothetical species is unknown.

A nitrogen mass balance was estimated for each experiment based on chemiluminescent NO_x concentrations determined initially and again during the 1700 EST hour of the first day. The nitrogen balances were similar to those for the propene- NO_x , $\text{CH}_3\text{SC}_2\text{H}_5$ - NO_x , and $\text{C}_2\text{H}_5\text{SH}$ - NO_x experiments. The fraction of initial NO_x that could be accounted for in the four $\text{C}_2\text{H}_5\text{SC}_2\text{H}_5$ - NO_x experiments ranged from 0.25 to 0.61 and increased with increasing initial HC/ NO_x ratios (i.e., decreasing initial NO_x concentrations). The unaccountable product nitrogen may be nitric acid or other undetermined nitrogen-containing species. The fate of NO_x in photochemically reacting systems is largely unknown.

The test species, $\text{C}_2\text{H}_5\text{SC}_2\text{H}_5$, was consumed rapidly during these experiments. Its concentration could be approximated by the difference between the total sulfur and the SO_2 concentrations. Estimates were made of the concentrations of $\text{C}_2\text{H}_5\text{SC}_2\text{H}_5$ that remained unreacted at the 1700 EST hour of the first day. The ordering of the concentrations of remaining $\text{C}_2\text{H}_5\text{SC}_2\text{H}_5$ was similar to that observed earlier for the fraction of NO_x that remained at the 1700 EST hour. In both cases the fractions of unreacted reactants increased with increasing initial HC/ NO_x ratios. The concentrations of remaining $\text{C}_2\text{H}_5\text{SC}_2\text{H}_5$ ranged from 0.02 to 0.31 ppmS. At the initial target HC/ NO_x ratio of 2 the smallest amount of $\text{C}_2\text{H}_5\text{SC}_2\text{H}_5$ could be accounted for. Inspection of the times to one-half consumption of $\text{C}_2\text{H}_5\text{SC}_2\text{H}_5$ also indicates that

the $C_2H_5SC_2H_5$ disappearance rate was dependent on the initial HC/NO_x ratio--increasing with decreasing ratios.

Sulfur dioxide was found as a product of the photooxidation of $C_2H_5SC_2H_5$ in the presence of NO_x in each of the four experiments, although only trace quantities of SO_2 were found in three of the experiments. The largest, and only, maximum SO_2 concentration was 0.12 ppm. It occurred at the target HC/NO_x ratio of 2 during the 1100 EST hour. The largest maximum concentrations of ozone, MN, EN, and PAN were also achieved in this experiment.

Moderate quantities of condensation nuclei were produced on the first day. Maximum concentrations ranged from 16000 to 58000 cm^{-3} and occurred during the 0800 EST hour in three of four cases. The largest maximum CN concentration occurred at the HC/NO_x ratio of 2. Maximum concentrations decreased with increasing HC/NO_x ratios (i.e., decreasing initial NO_x concentrations).

Conversion of $C_2H_5SC_2H_5$ to particulate sulfur was rapid, and maximum TPS concentrations were dependent on the initial HC/NO_x ratio. Maximum TPS concentrations were achieved during the 0900 EST hour. Only a small portion of the reacted test species was detected as particulate sulfur. Maximum TPS concentrations ranged from 24 to 64 $\mu g/m^3$ or the equivalent of 0.02 to 0.05 ppmS. The largest $[TPS]_{max}$, 64 $\mu g/m^3$, occurred at the target HC/NO_x ratio of 4, although it was not significantly larger than the corresponding value at the target ratio of 2. At the higher HC/NO_x ratios of 10 and 20, smaller $[TPS]_{max}$ values were generated. Maximum TPS concentrations generally decreased with increasing initial HC/NO_x ratios (i.e., decreasing initial NO_x concentrations).

The ratio of product sulfur as particulate to the total accountable reacted sulfur $[(TPS) \text{ plus } (SO_2)]$ could be determined for only one experiment. This ratio was based on data interpolated for the hour of occurrence of the maximum SO_2 concentration, and it permits an assessment of the distribution of accountable product sulfur between the gas and particulate phases. For the $C_2H_5SC_2H_5-NO_x$ system at the target HC/NO_x ratio of 2, this ratio was 0.16 indicating that in this case most of the accountable product sulfur existed as SO_2 . In addition, results in the appendix indicate that a substantial portion of the product sulfur cannot be accounted for.

The second day was mostly cloudy with 17 percent sunshine and a cumulative daily solar radiation of only 149 cal cm^{-2} . As a result, the photochemical behavior was somewhat subdued, and second-day concentrations of SO_2 , TPS, CN, and O_3 were less than the corresponding first-day levels. Sulfur dioxide was not detected on the second day. Maximum TPS concentrations ranged from 0 to $3.4 \mu\text{g/m}^3$ or 0 to 0.003 ppmS. In addition, second-day maximum CN concentrations did not exceed 300 cm^{-3} . Neither TPS nor CN maximum concentrations displayed any apparent trends with initial conditions. Second-day maximum ozone concentrations did not exceed the corresponding first-day maxima, although the ordering with respect to initial conditions was the same in both cases. Second-day ozone concentrations generally decayed from the elevated first-day levels. Net ozone concentrations ranged from 0.002 to 0.037 ppm. These small net ozone concentrations indicate that little ozone was generated under the cloudy conditions that prevailed on the second day.

Ethyl Disulfide

Mixtures of ethyl disulfide and NO_x were irradiated on 7 and 8 October 1977. On 7 October the cumulative daily solar radiation was 373 cal cm^{-2} with 34 percent of the possible minutes of direct sunshine and a maximum temperature of 22.2°C . Selected results from the $(\text{C}_2\text{H}_5\text{S})_2\text{-NO}_x$ experiments are summarized in Table 29. Concentration-time profiles of various reactants and products for the experiment conducted in Chamber No. 3 are presented in Figure 22.

The photochemical behavior of irradiated mixtures of NO_x and $(\text{C}_2\text{H}_5\text{S})_2$ was similar in many respects to that of irradiated mixtures of NO_x and hydrocarbons such as propene. In each of the $(\text{C}_2\text{H}_5\text{S})_2\text{-NO}_x$ experiments conversion of NO to NO_2 was rapid. The disulfides, ethyl and methyl, displayed the most rapid conversion of NO to NO_2 of all the species tested in the current study. For the experiments conducted with ethyl disulfide approximately 0.74 hours of irradiation were required to achieve NO- NO_2 crossover, and the maximum NO_2 concentration occurred during the 0700 EST hour. In contrast to the propene- NO_x system, the time to crossover displayed no apparent trends with the initial HC/ NO_x ratio. As with methyl disulfide, however, crossover was first achieved at the target HC/ NO_x ratio of 10.

TABLE 29. SUMMARY OF SELECTED RESULTS FROM SMOG CHAMBER EXPERIMENTS
CONDUCTED WITH $(C_2H_5S)_2$ AND NO_x

TEST COMPOUND ^{a/}	DATE ^{b/}	T_{max} ^{c/}	%SS ^{d/}	CU-SR ^{e/}	SUNRISE ^{f/}
Ethyl Disulfide ($C_2H_5S)_2$	10-7-77 10-8-77	22.2 18.9	34 29	373 88	6.18
SMOG CHAMBER NUMBER		3	4	1	2
FIRST DAY PARAMETERS					
Target Initial HC/ NO_x (ppmC/ppm)		2	4	10	20
Time of $NO-NO_2$ Crossover, (hrs EST)		6.89	7.12	6.68	6.98
$[NO_2]_{max}$, ppm		0.732	0.329	0.122	0.041
Time of $[NO_2]_{max}$, (hrs EST)		7.47	7.63	7.13	7.30
$[O_3]_{max}$, ppm		0.560	0.472	0.189	0.104
Time of $[O_3]_{max}$, (hrs EST)		15.47	15.63	15.13	15.30
$[PAN]_{max}$, ppm		0.200	0.191	0.051	0.040
Time of $[PAN]_{max}$, (hrs EST)		13.47	11.63	11.13	13.30
$[NM]_{ppm}$ ^{g/}		0.029	0.007	0	0
$[EM]_{ppm}$		0.047	0.010	0.007	0.004
$[NO_x]_{initial}$ ^{h/}		0.965	0.538	0.191	0.093
$[NO_x]$ @ 1700 EST		0.262	0.230	0.080	0.041
ENO_x @ 1700 EST ^{i/}		0.272	0.428	0.419	0.441
$[(C_2H_5S)_2]$ @ 1200 EST ^{j/}		0.089	0.094	0.128	0.164
Time of $[(C_2H_5S)_2]_k$ (hrs EST) ^{k/}		7.01	7.18	7.60	8.44
$[SO_2]_{max}$, ppm		0.729	0.651	0.552	0.614
Time of $[SO_2]_{max}$, (hrs EST)		7.47	7.63	11.13	12.30
$[TPS]_{max}$, $\mu g/m^3$		231.8	161.9	104.8	77.3
(ppmS)		0.177	0.124	0.080	0.059
Time of $[TPS]_{max}$, (hrs EST)		7.47	8.63	8.13	8.30
R ^{l/}		0.20	0.16	0.06	0.02
$[CN]_{max}$, cm^{-3}		27,000	25,000	56,000	41,000
Time of $[CN]_{max}$, (hrs EST)		7.47	11.63	10.13	10.30
Night-time O_3 Half-Life (hrs) ^{n/}		9	9	3 ^{a/}	3 ^{a/}

(continued)

NOTES: Abbreviations: ND = no data are available; NA = not applicable;
0 = not detected; tr = detected, but not quantified; X = concentration decreased, no maximum observed.

The appendix should be consulted for additional data that are not summarized in this table.

TABLE 29. (continued)

SMOG CHAMBER NUMBER	3	4	1	2
SECOND DAY PARAMETERS				
$[O_3]_{\max}$, ppm	0.200	0.172	0.055	0.045
ΔO_3 , ppm ^{a/}	0.048	0.038	0.048	0.041
$[SO_2]_{\max}$, ppm	ND	ND	ND	ND
ΔSO_2 , ppm ^{a/}	NA	NA	NA	NA
$[TPS]_{\max}$, $\mu\text{g}/\text{m}^3$	0	3.0	20.3	3.1
(ppmS)	0	0.002	0.016	0.002
$[CN]_{\max}$, cm^{-3}	10,700	4,600	5,700	3,100

^{a/} Target initial concentration 2.0 ppmC, 0.5 ppm (V/V), or 1.0 ppmS.

^{b/} Dates of first and second days of the experiment.

^{c/} Daily maximum temperature in °C.²⁹

^{d/} Duration of direct solar radiation reported as percent of possible minutes of sunshine.²⁹

^{e/} Cumulative daily solar radiation expressed in Langleys (cal cm^{-2}); note that the second-day value is the cumulative solar radiation on that day until the experiment was terminated--usually 1700 EST.

^{f/} Time of sunrise in hours (EST); since the times of sunrise are approximately the same for both days, the time is given for the first day only.

^{g/} Daily median concentrations of species tentatively identified to be methyl and ethyl nitrate; they are not listed in the appendix.

^{h/} The initial $[NO]$ is taken to be the concentration that existed at approximately the time of sunrise^x; the table entry has NOT been corrected for possible interferences.

^{i/} Fraction of initial NO remaining at the 1700 EST hour calculated from NO_x concentrations as determined by the chemiluminescent NO_x analyzer.

^{j/} Concentration of accountable test compound at the 1200 EST hour.

^{k/} Estimate of the time at which approximately one-half of the test compound was consumed.

^{l/} Ratio of product sulfur as particulate to the total accountable reacted sulfur at the time of $[SO_2]_{\max}$: $(([TPS]/([TPS]+[SO_2])))$.

^{m/} Estimate of ozone half-life based on data collected during the 2000 EST hour of the first day and the 0400 EST hour of the second day: $t_{1/2} \approx 5.545/\ln([O_3]_{2000}/[O_3]_{0400})$.

^{n/} This half-life may be suspect, since ozone concentrations smaller than 0.1 ppm were involved in its determination.

^{o/} Net concentration on the second day is the difference between the second-day maximum concentration and the preceding minimum concentration: $\Delta O_3 = [O_3]_{\max} - [O_3]_{\min}$ and $\Delta SO_2 = [SO_2]_{\max} - [SO_2]_{\min}$.

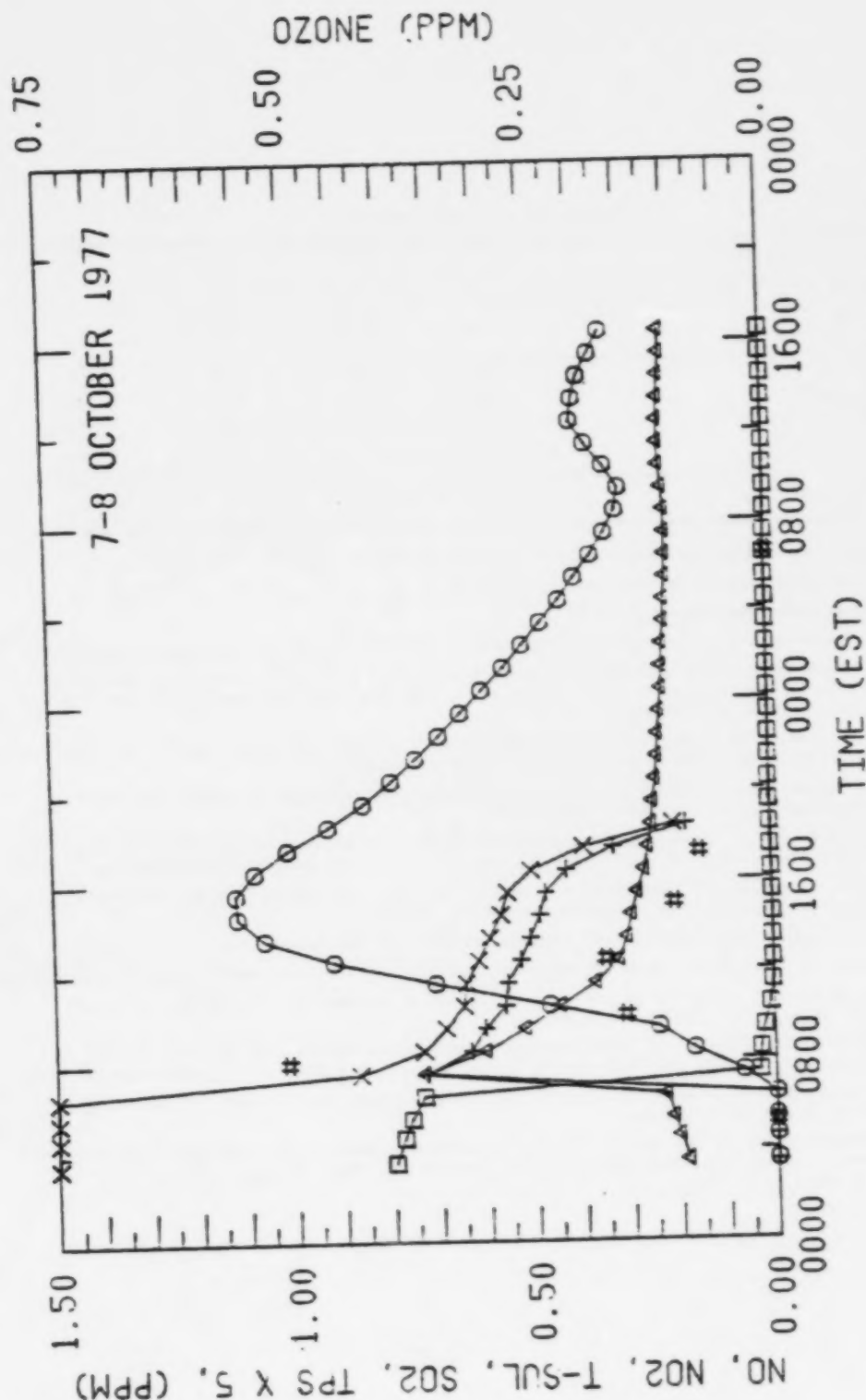


Figure 22. Concentration-time profiles of various reactants and products for the 7 and 8 October 1977 (C₂H₅S)₂-NO_x experiments conducted in RTI Chamber No. 3. Target initial conditions: 2.0 ppmC (C₂H₅S)₂ and 1.0 ppm NO_x. Symbol key: (○) O₃; (□) NO; (Δ) NO₂; (x) Total Sulfur; (+) SO₂; and (#) TPS.

Ozone accumulated during each experiment. Maximum concentrations were dependent on the initial HC/NO_x ratio. Ozone maxima occurred during the 1500 EST hour and ranged from 0.10 to 0.56 ppm. The largest [O₃]_{max}, 0.56 ppm, was achieved at the target HC/NO_x ratio of 2. Maximum ozone concentrations decreased with increasing initial HC/NO_x ratio (i.e., decreasing initial NO_x concentration).

In contrast to the experiments conducted with methyl disulfide, where neither PAN nor EN were detected, PAN, MN, and EN were found as reaction products in the experiments with ethyl disulfide. At the target HC/NO_x ratios of 4 and 10, maximum PAN concentrations were achieved during the 1100 EST hour--approximately two hours before they were achieved at ratios of 2 and 20. Maximum PAN as well as median MN and EN concentrations were dependent on the initial HC/NO_x ratio. The largest concentrations of these species occurred at the target HC/NO_x ratio of 2 and decreased with increasing HC/NO_x ratios (i.e., with decreasing initial NO_x concentrations). For the four experiments the ordering of the PAN, MN, and EN concentrations with respect to initial HC/NO_x ratio was similar to that of the maximum ozone concentrations. In addition, the ordering of MN and EN with respect to initial HC/NO_x ratio was similar to that observed for the ethanethiol and the ethyl sulfide experiments. The tentative identification of MN and EN in addition to the identification of PAN suggests that the photooxidation of ethyl disulfide involves the cleavage of the ethyl-sulfur bond, which in the presence of air and NO_x leads to the formation of MN, EN, and PAN.

Inspection of the first-day NO_x data in the appendix revealed unusual behavior. At the two highest initial HC/NO_x ratios, between 0800 and 1200 EST, the NO_x concentration exhibited a loss of approximately 10 ppb and a subsequent recovery. The timing of this phenomenon coincided with the initial buildup of PAN. This behavior was not observed in the remaining two experiments, although it may have been obscured by the higher NO_x concentrations employed in these experiments. It is likely that a transient nitrogen-containing species was responsible for this behavior. This species was either not delivered to the NO_x monitor as a result of interactions with chamber walls or the sampling system, or it could not be detected by the chemiluminescent NO_x monitor that was employed. At any rate, the identity of this hypothetical species is unknown.

A nitrogen mass balance was estimated for each experiment based on chemiluminescent NO_x concentrations determined initially and again during the 1700 EST hour of the first day. The nitrogen balances were similar to those for the propene- NO_x , $\text{CH}_3\text{SC}_2\text{H}_5$ - NO_x , CH_5SH - NO_x , and $\text{C}_2\text{H}_5\text{SC}_2\text{H}_5$ - NO_x experiments. For the four $(\text{C}_2\text{H}_5\text{S})_2$ - NO_x experiments, the fraction of initial NO_x that could be accounted for ranged from 0.27 to 0.44 and with a single exception generally increased with increasing HC/NO_x ratios (i.e., decreasing initial NO_x concentrations). The unaccountable product nitrogen may be nitric acid or other undetermined nitrogen-containing species. The fate of NO_x in photochemically reacting systems is largely unknown.

Initially, the total sulfur concentration exceeded the linear range of the sulfur instrument. The test species, $(\text{C}_2\text{H}_5\text{S})_2$, was consumed rapidly during these experiments, and by the 0700 EST hour its concentration could be approximated by the difference between the total sulfur and the SO_2 concentrations. Since reaction was very rapid, estimates were made of the concentrations of $(\text{C}_2\text{H}_5\text{S})_2$ that remained unreacted at the 1200 EST hour of the first day. The ordering of the concentrations of remaining $(\text{C}_2\text{H}_5\text{S})_2$ was similar to that observed earlier for the fraction of remaining NO_x (at the 1700 EST hour). In both cases the fractions of unreacted reactants increased with increasing initial HC/NO_x ratios. For the four experiments the concentrations of remaining $(\text{C}_2\text{H}_5\text{S})_2$ ranged from 0.09 to 0.16 ppmS. At the initial target HC/NO_x ratio of 2, the smallest amount of $(\text{C}_2\text{H}_5\text{S})_2$ could be accounted for, although it was not significantly smaller than the corresponding value at the target ratio of four. Inspection of the times to one-half consumption of $(\text{C}_2\text{H}_5\text{S})_2$ also indicates that the $(\text{C}_2\text{H}_5\text{S})_2$ disappearance rate was dependent on the initial HC/NO_x ratio--increasing with decreasing ratios.

In each of the four experiments sulfur dioxide was found as a product of the photooxidation of $(\text{C}_2\text{H}_5\text{S})_2$ in the presence of NO_x . Maximum concentrations and their times of occurrence were dependent on the initial HC/NO_x ratio. Sulfur dioxide maxima ranged from 0.55 to 0.73 ppm. Maximum concentrations were first achieved during the 0700 EST hour at target ratios of two and four. The times required to reach $[\text{SO}_2]_{\text{max}}$ increased with increasing HC/NO_x ratios. The largest $[\text{SO}_2]_{\text{max}}$ was 0.73 ppm and was achieved at the target HC/NO_x ratio of 2. With a single exception, maximum SO_2 concentrations decreased with increasing initial HC/NO_x ratios. Other reaction

products such as ozone, PAN, MN, and EN, exhibited similar behavior in which decreasing maximum concentrations were associated with increasing initial HC/NO_x ratios.

Moderate quantities of condensation nuclei were produced on the first day. Maximum concentrations ranged from 25000 to 56000 cm⁻³ and generally occurred before 1200 EST. The largest maximum CN concentration occurred at the HC/NO_x ratio of 10; however, there were no apparent trends between maximum CN concentrations and initial conditions.

Conversion of (C₂H₅S)₂ to particulate sulfur was rapid, and maximum TPS concentrations were dependent on the initial HC/NO_x ratio. Maximum TPS concentrations were achieved before 0900 EST. Only a small portion of the reacted test species was detected as particulate sulfur. Maximum TPS concentrations ranged from 77 to 232 µg/m³, the equivalent of 0.06 to 0.18 ppmS, and decreased with increasing initial HC/NO_x ratios (i.e., decreasing initial NO_x concentrations). The largest [TPS]_{max}, 232 µg/m³, occurred at the target HC/NO_x ratio of 2.

The ratio of product sulfur as particulate to the total accountable reacted sulfur ([TPS]_{max} plus [SO₂]_{max}) was determined for each experiment. This ratio was based on data collected during or interpolated for the hour of occurrence of the maximum SO₂ concentration, and it permits an assessment of the distribution of accountable product sulfur between the gas and particulate phases. For the (C₂H₅S)₂-NO_x system this ratio was small, ranging from 0.02 to 0.20, and it decreased with increasing initial HC/NO_x ratios (i.e., decreasing initial NO_x concentrations). Thus, most of the accountable product sulfur existed as SO₂, and SO₂ comprised increasing proportions with increasing initial HC/NO_x ratios. In addition, results in the appendix suggest that a substantial portion of the product sulfur cannot be accounted for.

The second-day was mostly cloudy with 29 percent sunshine and a cumulative daily solar radiation of only 88 cal cm⁻². As a result, the photochemical behavior was somewhat subdued and second-day concentrations of TPS, CN, and O₃ were less than the corresponding first-day levels. Maximum TPS concentrations ranged from 0 to 20.3 µg/m³ or 0 to 0.02 ppmS. In addition, second-day maximum CN concentrations ranged from 3100 to 10700 cm⁻³. Neither TPS nor CN maximum concentrations displayed any apparent trends with

initial conditions. Second-day SO_2 data were not available. The ordering of second-day ozone maxima with respect to initial conditions was the same as that of the first-day maxima. This behavior largely reflects the decay of ozone concentrations from the first-day maxima. Net ozone concentrations were almost identical for the four experiments and ranged from 0.038 to 0.048 ppm. These small net ozone concentrations indicate that little ozone was generated under the cloudy conditions that prevailed on the second day.

Thiophene

Mixtures of thiophene and NO_x were irradiated on 17, 18, and 19 October, and an additional thiophene- NO_x experiment was conducted on 18 and 19 November 1977. In general, only the October experiments are considered in the current discussion. On 17 October the cumulative daily solar radiation was 425 cal cm^{-2} with 98 percent of the possible minutes of direct sunshine and a maximum temperature of 13.9°C . Selected results from the October $\text{C}_4\text{H}_4\text{S}$ - NO_x experiments are summarized in Table 30. Concentration-time profiles of various reactants and products for the 17 October experiment conducted in Chamber No. 1 are presented in Figure 23.

The photochemical behavior of irradiated mixtures of NO_x and $\text{C}_4\text{H}_4\text{S}$ was similar in various respects to that of irradiated mixtures of NO_x and hydrocarbons such as propene. The time of occurrence of NO - NO_2 crossover was strongly dependent on the initial HC/NO_x ratio. Crossover was first achieved at the target HC/NO_x ratio of 20 at approximately 0854 EST. The duration of irradiation required to achieve NO - NO_2 crossover increased with decreasing initial HC/NO_x ratios, and at the target ratio of 2, crossover was not achieved until 1304 EST on the second day (18 October). The timing of the maximum NO_2 concentrations was also strongly dependent on the initial HC/NO_x ratio and generally occurred within 2 hours after NO - NO_2 crossover.

Ozone accumulated during each experiment. Maximum concentrations and their times of occurrence were dependent on the initial HC/NO_x ratio. Ozone maxima ranged from 0.002 to 0.124 ppm. The largest maximum ozone concentration, 0.12 ppm, occurred at the target HC/NO_x ratio of 10. As the initial HC/NO_x ratio was moved away from 10, maximum ozone concentrations decreased. At the target HC/NO_x ratio of 2 the system was rich in NO_x and "NO inhibited," failed to achieve crossover, and produced negligible amounts of ozone.

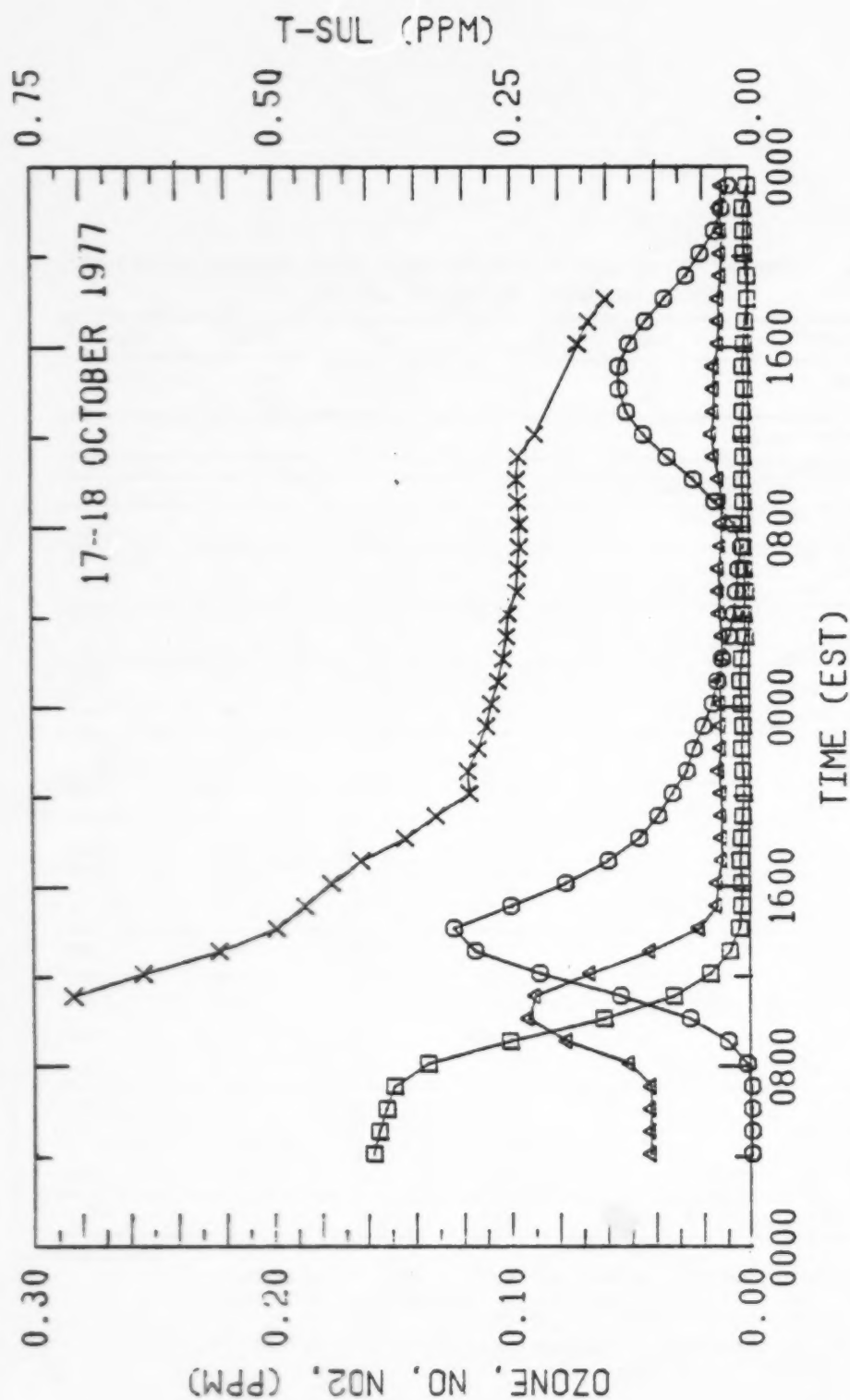


Figure 23. Concentration-time profiles of various reactants and products for the 17 and 18 October 1977 thiophene-NO_x experiment conducted in RTI Chamber No. 1. Target initial conditions: 2.0 ppmC thiophene and 0.2 ppm NO_x. Symbol key: (o) O₃; (□) NO; (Δ) NO₂; and (x) Total Sulfur.

TABLE 30. SUMMARY OF SELECTED RESULTS FROM SMOG CHAMBER EXPERIMENTS
CONDUCTED WITH THIOPHENE AND NO_x

TEST COMPOUND ^{a/}	DATE ^{b/}	T _{max} °C ^{c/}	%SS ^{d/}	CU-SR ^{e/}	SUNRISE ^{f/}
Thiophene	10-17-77	13.9	98	425	6.37
C ₄ H ₄ S	10-18-77	20.0	92	397	
SMOG CHAMBER NUMBER		3	4	1	2
FIRST DAY PARAMETERS					
Target Initial HC/NO _x (ppmC/ppm)		2	4	10	20
Time of NO-NO ₂ Crossover, (hrs EST)		13.07 ^{g/}	11.95	9.57	8.90
[NO ₂] _{max} , ppm		0.291	0.213	0.093	0.051
Time of [NO ₂] _{max} , (hrs EST)		15.47	13.63	10.13	9.30
[O ₃] _{max} , ppm		0.002	0.017	0.124	0.112
Time of [O ₃] _{max} , (hrs EST)		NA	14.63	14.13	11.30
[PAN] _{max} , ppm		0.001	0.002	0.007	0.002
Time of [PAN] _{max} , (hrs EST)		NA	NA	NA	NA
[MN] ppm ^{g/}		0	0	0	0
[EN] ppm		0.001	tr	0	0
[NO] _x initial ^{h/}		0.974	0.496	0.194	0.101
[NO] _x @ 1700 EST		0.737	0.296	0.017	0.013
[NO] _x @ 1700 EST ^{i/}		0.757	0.597	0.088	0.129
[C ₄ H ₄ S] @ 1200 EST ^{j/}		0.834	0.784	0.701	0.712
Time of [C ₄ H ₄ S] _{1/2} (hrs EST) ^{k/}		7.93 ^{g/}	22.96	13.80	16.30
[SO ₂] _{max} , ppm ^{g/}		0.050	0.060	0.078	0.096
Time of [SO ₂] _{max} , (hrs EST) ^{g/}		15.47	15.63	15.13	15.30
[TPS] _{max} , µg/m ³		11.4	10.6	24.1	15.2
(ppmS)		0.009	0.008	0.018	0.012
Time of [TPS] _{max} , (hrs EST)		14.47	14.63	14.13	10.30
R ^{l/}		0.14	0.12	0.18	0.09
[CN] _{max} , cm ⁻³		21,000	16,000	14,000	10,300
Time of [CN] _{max} , (hrs EST)		8.47	8.63	8.13	8.30
Night-time O ₃ Half-Life (hrs) ^{m/}		NA	NA	4 ^{n/}	4 ^{n/}

(continued)

NOTES: Abbreviations: ND = no data are available; NA = not applicable;
0 = not detected; tr = detected, but not quantified; X = concentration decreased, no maximum observed.

The appendix should be consulted for additional data that are not summarized in this table.

TABLE 30. (continued)

SMOG CHAMBER NUMBER	3	4	1	2
SECOND DAY PARAMETERS				
$[O_3]_{\max}$, ppm	0.007	0.083	0.055	0.060
ΔO_3 , ppm ^{a/}	0.007	0.083	0.051	0.057
$[SO_2]_{\max}$, ppm ^{g/}	0.072	0.067	tr	0.071
ΔSO_2 , ppm ^{a, g/}	0.072	0.067	NA	0.071
$[TPS]_{\max}$, $\mu\text{g}/\text{m}^3$	4.8	8.1	0	5.6
(ppmS)	0.004	0.006	0	0.004
$[CN]_{\max}$, cm^{-3}	2,000	2,200	6,000	4,350

^{a/} Target initial concentration 2.0 ppmC, 0.5 ppm (V/V), or 0.5 ppmS.

^{b/} Dates of first and second days of the experiment.

^{c/} Daily maximum temperature in °C.²⁹

^{d/} Duration of direct solar radiation reported as percent of possible minutes of sunshine.²⁹

^{e/} Cumulative daily solar radiation expressed in Langleys (cal cm^{-2}); note that the second-day value is the cumulative solar radiation on that day until the experiment was terminated--usually 1700 EST.

^{f/} Time of sunrise in hours (EST); since the times of sunrise are approximately the same for both days, the time is given for the first day only.

^{g/} Daily median concentrations of species tentatively identified to be methyl and ethyl nitrate; they are not listed in the appendix.

^{h/} The initial $[NO_x]$ is taken to be the concentration that existed at approximately the time of sunrise^x; the table entry has NOT been corrected for possible interferences.

^{i/} Fraction of initial NO_x remaining at the 1700 EST hour calculated from NO_x concentrations as determined by^x the chemiluminescent NO_x analyzer.

^{j/} Fraction of accountable test compound at the 1200 EST hour.

^{k/} Estimate of the time at which approximately one-half of the test compound was consumed.

^{l/} Ratio of product sulfur as particulate to the total accountable reacted sulfur at the time of $[SO_2]_{\max}$: $([TPS]/([TPS]+[SO_2]))$.

^{m/} Estimate of ozone half-life based on data collected during the 2000 EST hour of the first day and the 0400 EST hour of the second day: $t_{1/2} \approx 5.545/\ln ([O_3]_{2000}/[O_3]_{0400})$.

^{n/} This half-life may be suspect, since ozone concentrations smaller than 0.1 ppm were involved in its determination.

^{o/} Net concentration on the second day is the difference between the second-day maximum concentration and the preceding minimum concentration: $\Delta O_3 = [O_3]_{\max} - [O_3]_{\min}$ and $\Delta SO_2 = [SO_2]_{\max} - [SO_2]_{\min}$.

^{p/} On the second day (18 October).

^{q/} Since few SO_2 concentration data are available, these data may not truly represent maximum values.

Among the remaining 3 cases, as the initial HC/NO_x ratio was increased the maximum ozone concentration was achieved more rapidly.

In contrast to the experiments conducted with the open-chain sulfur species that produced significant amounts of PAN, MN, and EN, the concentrations of PAN and EN were very small in the experiments conducted with thiophene, and MN was not detected. Although the PAN and EN concentrations displayed trends with the various initial conditions, the low concentrations involved do not provide strong evidence for these trends. The largest maximum PAN concentration occurred at the target HC/NO_x ratio of 10 and decreased as this ratio was moved away from 10. The ordering of the maximum PAN concentrations with respect to initial HC/NO_x ratio was similar to that of the maximum ozone concentrations. The absence of MN and the very low concentrations of PAN and EN observed as products of thiophene photooxidation suggest that few precursor radicals of these nitrates were produced. Comparison of the chemical structures of thiophene and the open-chain sulfur species suggests that the formation of the free radicals necessary to produce PAN, MN, and EN is more complex for thiophene. It is likely that the major oxidation steps for thiophene resulted in ring cleavage and the formation of relatively complex radicals. Subsequent degradation of these radicals in the presence of NO_x probably accounted for the observed PAN and EN concentrations.

A nitrogen mass balance was estimated for each experiment based on chemiluminescent NO_x concentrations determined initially and again during the 1700 EST hour of the first day. For the four C₄H₄S-NO_x experiments the fraction of initial NO_x that could be accounted for ranged from 0.09 to 0.76. The nitrogen balances were similar to those for the propene-NO_x experiments--in general the nitrogen balance was the poorest for those conditions under which high ozone concentrations were generated. At the 1700 EST hour only 0.09 of the original NO_x could be accounted for at the target HC/NO_x ratio of 10. The accountable fraction increased as target ratios were moved away from 10. The absence of MN and the low concentrations of PAN and EN, coupled with the poor nitrogen balances raise questions concerning the fate of NO_x in the thiophene-NO_x experiments. The unaccountable product nitrogen may be nitric acid or other undetermined nitrogen species. The fate of NO_x in photochemically reacting systems is largely unknown.

The test species, C_4H_4S , was consumed slowly during these experiments. Its concentration could be approximated by the difference between the total sulfur and the SO_2 concentrations. Estimates were made of the fraction of initially present C_4H_4S that remained unreacted at the 1200 EST hour of the first day. For the four experiments the fraction of initial C_4H_4S that could be accounted for ranged from 0.70 to 0.83. The ordering of the accountable fractions of C_4H_4S was similar to that observed earlier for the fractions of NO_x remaining at the 1700 EST hour. In both cases the fractions of unreacted reactant were the smallest at the target HC/NO_x ratio of 10 and increased as the target ratios were moved away from 10. Times to one-half consumption of C_4H_4S also indicates that the C_4H_4S disappearance rate was dependent on the initial HC/NO_x ratio--it was the most rapid at the target HC/NO_x ratio of 10, and it became less rapid as this ratio was moved away from 10.

Sulfur dioxide was found as a product of the photooxidation of C_4H_4S in the presence of NO_x in each of the four experiments. Since SO_2 concentration data are available only through the 1500 EST hour on 17 October, it is uncertain whether the maximum concentrations through this hour were identical to the daily maxima. The available SO_2 maxima occurred during the 1500 EST hour and ranged from 0.050 to 0.096 ppm. The largest $[SO_2]_{max}$ was 0.096 ppm and occurred at the target HC/NO_x ratio 20.

Moderate quantities of condensation nuclei were produced on the first day, 17 October. Maximum concentrations ranged from 10800 to 21000 cm^{-3} and occurred during the 0800 EST hour. The largest maximum CN concentration occurred at the HC/NO_x ratio of 2. CN maxima decreased with increasing HC/NO_x ratios.

Maximum TPS concentrations and their times of occurrence were dependent on the initial HC/NO_x ratio. In the experiment conducted at the target HC/NO_x ratio of 20, $[TPS]_{max}$ was achieved during the 1000 EST hour; however, at the three smaller ratios the maximum concentrations were achieved after noon during the 1400 EST hour. Only a small portion of the reacted test species was detected as particulate sulfur, and the maximum TPS concentrations ranged between 11 and 24 $\mu g/m^3$ or the equivalent of 0.008 to 0.018 ppmS. The ordering of the maximum $[TPS]_{max}$ with respect to the initial HC/NO_x ratio was similar to that of the maximum ozone and PAN concentrations. The

largest maximum $[\text{TPS}]_{\text{max}}$ occurred at the initial HC/NO_x ratio of 10 and generally decreased as this ratio was moved away from 10.

The ratio of product sulfur as particulate to the total accountable reacted sulfur ($[\text{TPS}]$ plus $[\text{SO}_2]$) was determined for each experiment. This ratio was based on data collected during or interpolated for the hour of occurrence of the maximum SO_2 concentration, and it permits an assessment of the distribution of accountable product sulfur between the gas and particulate phases. For the $\text{C}_4\text{H}_4\text{S}-\text{NO}_x$ system this ratio was small, ranging from 0.09 to 0.18. The largest ratio, 0.18, occurred at the target HC/NO_x ratio of 10. In addition, results in the appendix suggest that a substantial portion of the product sulfur cannot be accounted for.

Second-day cumulative solar radiation values were high during both the October and November thiophene- NO_x experiments. Maximum TPS concentrations on 18 October ranged from 0 to $8.1 \mu\text{g}/\text{m}^3$ or 0 to 0.006 ppmS. The largest second-day maximum TPS concentration was achieved at the target HC/NO_x ratio of 4. The maximum CN concentrations were also low on 18 October, ranging from 2000 to 6000 cm^{-3} . However, on 19 November the maximum CN concentration of 29000 cm^{-3} approached the first-day value. No apparent associations with initial conditions were noted for second-day maximum TPS or CN concentrations. Sulfur dioxide concentration data were available for only 3 to 4 hours on 18 October. Thus, it is uncertain whether the maxima from these available data were identical to the daily maxima. Since it is likely that the SO_2 concentrations decayed to trace amounts during the evening and night of the first day, second-day maximum and net concentrations were assumed to have been identical. In the three cases where the first-day $\text{C}_4\text{H}_4\text{S}$ consumption had been the least complete, the available second-day SO_2 maxima were approximately equal (0.07 ppm). They slightly exceeded the corresponding first day maxima at target HC/NO_x ratios of 2 and 4, but did not do so at 20. At the target ratio of 10, where first-day thiophene consumption had been the most complete, only trace amounts of SO_2 were found on the second day. Second-day maximum and net ozone concentrations exceeded the first-day maxima on 18 October at the target HC/NO_x ratios of 2 and 4, and also on 19 November at target HC/NO_x ratio of 6.7. On 18 October the net ozone concentrations ranged from 0.007 to 0.083 ppm. Previous experiments with the thiophene- NO_x

system conducted at RTI have also indicated that for static (nondilution) conditions, second-day net and maximum ozone concentrations can exceed first-day maxima.⁴² For the three cases in the current study where this occurred, the target HC/NO_x ratios (2, 4, and 6.7) were sufficiently low that NO_x was in relative excess on the first day, and thus, only small quantities of ozone accumulated under the prevailing light-limited conditions. By the second day, much of the initial NO had been converted to NO₂, the systems were no longer as severely light-limited, and significantly higher concentrations of ozone accumulated. Thus, the high initial NO_x concentrations that inhibited ozone production on the first day resulted in enhanced ozone production on the second day. As an example, the largest net ozone concentration, 0.083 ppm, was achieved at the target HC/NO_x ratio of 4 rather than 10 where the largest first-day ozone maximum had occurred.

2-Methylthiophene

Mixtures of 2-methylthiophene and NO_x were irradiated on 30 and 31 October, and an additional experiment was conducted on 18 and 19 November 1977. In general, only the October experiments are considered in the current discussion. On 30 October the cumulative daily solar radiation was 349 cal cm⁻² with 90 percent of the possible minutes of direct sunshine and a maximum temperature of 17.8° C. Selected results from the October 2-methylthiophene-NO_x experiments are summarized in Table 31. Concentration-time profiles of various reactants and products for the 30 October experiment conducted in Chamber No. 2 are presented in Figure 24.

The photochemical behavior of irradiated mixtures of NO_x and 2-methylthiophene was similar in many respects to that of irradiated mixtures of NO_x and hydrocarbons such as propene. In each of the 2-methylthiophene-NO_x experiments, conversion of NO to NO₂ was rapid. The time of occurrence of NO-NO₂ crossover was dependent on the initial HC/NO_x ratio. The duration of irradiation required to achieve crossover increased with decreasing initial HC/NO_x ratios--generally, each of the tested thiophenes exhibited similar behavior. Crossover was first achieved at the target HC/NO_x ratio of 20. For the 4 experiments crossover occurred between 0857 and 1233 EST, requiring 2.3 to 5.9 hours of irradiation. The timing of the maximum NO₂ concentration was also dependent on the initial HC/NO_x ratio and generally occurred within the hour following crossover.

TABLE 31. SUMMARY OF SELECTED RESULTS FROM SMOG CHAMBER EXPERIMENTS
CONDUCTED WITH 2-METHYLTHIOPHENE AND NO_x

TEST COMPOUND ^{a/}	DATE ^{b/}	T _{max} ^{c/}	%SS ^{d/}	CU-SR ^{e/}	SUNRISE ^{f/}
2-Methylthiophene	10-30-77	17.8	90	349	6.62
C ₆ H ₄ S	10-31-77	16.1	49	243	
SMOG CHAMBER NUMBER		4	3	2	1
FIRST DAY PARAMETERS					
Target Initial HC/NO _x (ppmC/ppm)		2	4	10	20
Time of NO-NO ₂ Crossover, (hrs EST)		12.56	10.20	9.25	8.96
[NO ₂] _{max} , ppm		0.386	0.253	0.104	0.051
Time of [NO ₂] _{max} , (hrs EST)		13.63	11.47	10.30	9.13
[O ₃] _{max} , ppm		0.006	0.084	0.129	0.073
Time of [O ₃] _{max} , (hrs EST)		12.63	14.47	12.30	10.13
[PAN] _{max} , ppm		0.006	0.016	0.023	0.013
Time of [PAN] _{max} , (hrs EST)		13.63	16.47	13.30	13.13
[H ₂] ppm ^{g/}		ND	0.002	tr	tr
[EN] ppm		0	0	0	0
[NO] _x initial ^{h/}		0.980	0.500	0.206	0.114
[NO] _x @ 1700 EST		0.588	0.155	0.044	0.026
ENO _x @ 1700 EST ^{i/}		0.600	0.310	0.214	0.228
[C ₆ H ₄ S] @ 1200 EST ^{j/}		0.500	0.438	0.488	0.551
Time of [C ₆ H ₄ S] _y (hrs EST) ^{k/}		12.63	11.74	12.15	12.39
[SO ₂] _{max} , ppm		0.048	0.053	0.089	tr
Time of [SO ₂] _{max} , (hrs EST)		16.63	16.47	14.30	NA
[TPS] _{max} , µg/m ³		24.6	28.9	29.3	21.6
(ppm ^{l/})		0.019	0.022	0.022	0.017
Time of [TPS] _{max} , (hrs EST)		11.63	13.47	11.30	11.13
R ^{1/}		0.13	0.15	0.13	NA
[CH] _{max} , cm ⁻³		33,500	29,000	26,000	26,000
Time of [CH] _{max} , (hrs EST)		7.63	7.47	7.30	7.13
Night-time O ₃ Half-Life (hrs) ^{m/}		NA	2 ^{n/}	5 ^{n/}	3 ^{n/}

NOTES: Abbreviations: ND = no data are available; NA = not applicable;
0 = not detected; tr = detected, but not quantified; X = concentration decreased, no maximum observed.

The appendix should be consulted for additional data that are not summarized in this table.

(continued)

TABLE 31. (continued)

SMOG CHAMBER NUMBER	4	3	2	1
SECOND DAY PARAMETERS				
$[O_3]_{\max}$, ppm	0.007	0.120	0.077	0.027
ΔO_3 , ppm ^{a/}	0.007	0.120	0.064	0.026
$[SO_2]_{\max}$, ppm	tr	tr	tr	tr
ΔSO_2 , ppm ^{a/}	NA	NA	NA	NA
$[TPS]_{\max}$, $\mu g/m^3$	14.4	2.8	0	0
(ppmS)			0	0
$[CN]_{\max}$, cm^{-3}	3,600	6,000	13,500	10,700

^{a/} Target initial concentration 2.0 ppmC, 0.4 ppm (V/V), or 0.4 ppmS.

^{b/} Dates of first and second days of the experiment.

^{c/} Daily maximum temperature in °C.²⁹

^{d/} Duration of direct solar radiation reported as percent of possible minutes of sunshine.²⁹

^{e/} Cumulative daily solar radiation expressed in Langley (cal cm^{-2}); note that the second-day value is the cumulative solar radiation on that day until the experiment was terminated--usually 1700 EST.

^{f/} Time of sunrise in hours (EST); since the times of sunrise are approximately the same for both days, the time is given for the first day only.

^{g/} Daily median concentrations of species tentatively identified to be methyl and ethyl nitrate; they are not listed in the appendix.

^{h/} The initial $[NO_x]$ is taken to be the concentration that existed at approximately the time of sunrise; the table entry has NOT been corrected for possible interferences.

^{i/} Fraction of initial NO_x remaining at the 1700 EST hour calculated from NO_x concentrations as determined by the chemiluminescent NO_x analyzer.

^{j/} Fraction of accountable test compound at the 1200 EST hour.

^{k/} Estimate of the time at which approximately one-half of the test compound was consumed.

^{l/} Ratio of product sulfur as particulate to the total accountable reacted sulfur at the time of $[SO_2]_{\max}$: $([TPS]/([TPS]+[SO_2]))$.

^{m/} Estimate of ozone half-life based on data collected during the 2000 EST hour of the first day and the 0400 EST hour of the second day: $t_{1/2} \approx 5.545/\ln([O_3]_{2000}/[O_3]_{0400})$.

^{n/} This half-life may be suspect, since ozone concentrations smaller than 0.1 ppm were involved in its determination.

^{o/} Net concentration on the second day is the difference between the second-day maximum concentration and the preceding minimum concentration: $\Delta O_3 = [O_3]_{\max} - [O_3]_{\min}$ and $\Delta SO_2 = [SO_2]_{\max} - [SO_2]_{\min}$.

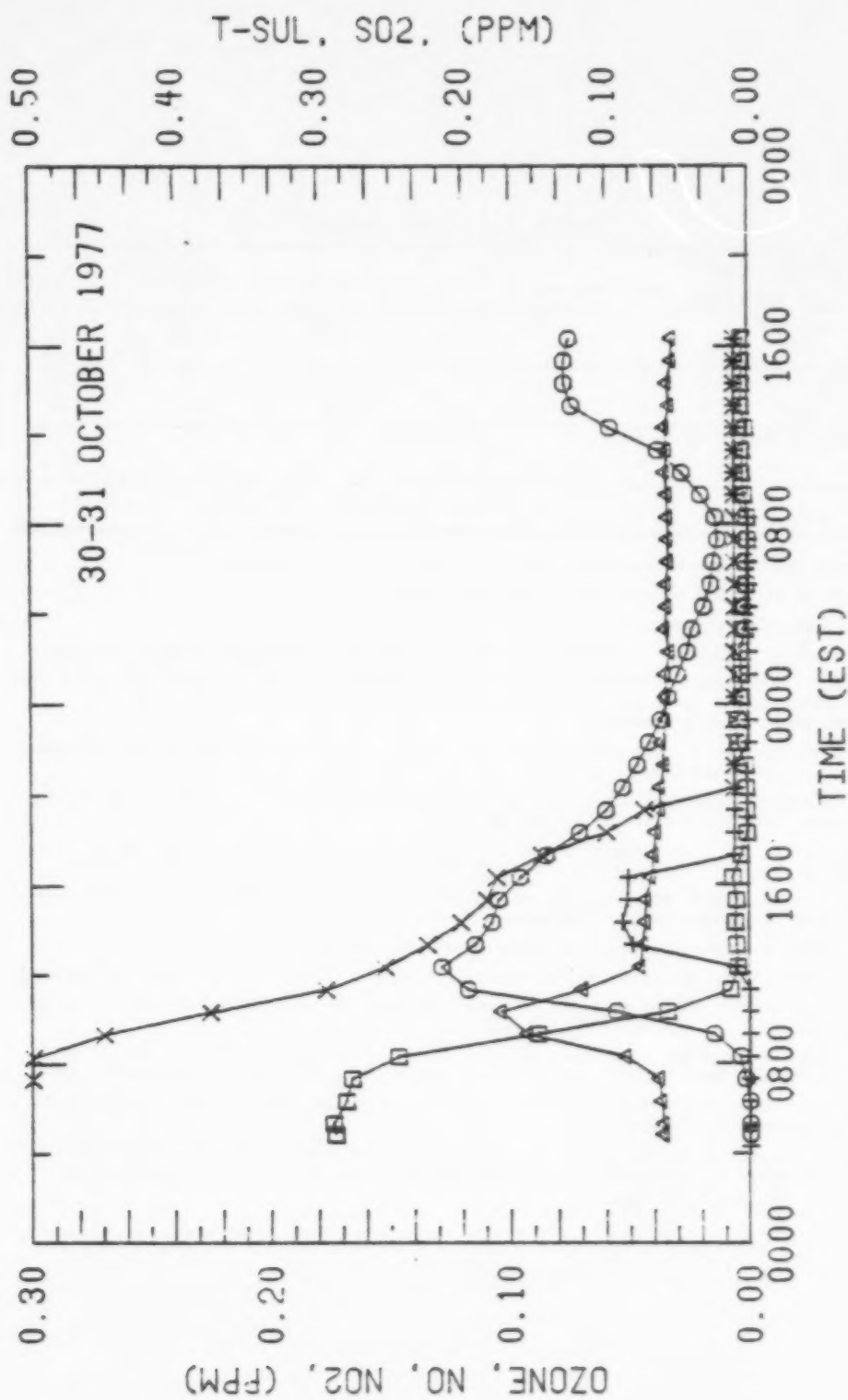


Figure 24. Concentration-time profiles of various reactants and products for the 30 and 31 October 1977 2-methylthiophene-NO_x experiment conducted in RTI Chamber No. 2. Target initial conditions: 2.0 ppmC 2-methylthiophene and 0.2 ppm NO_x. Symbol key: (o) O₃; (□) NO; (Δ) NO₂; (x) Total Sulfur; and (+) SO₂.

Ozone accumulated during each experiment. Maximum concentrations and their times of occurrence were dependent on the initial HC/NO_x ratio. Ozone maxima ranged from 0.006 to 0.129 ppm. A maximum ozone concentration was first achieved at the target HC/NO_x ratio of 20 during the 1000 EST hour. At the lower ratios ozone maxima were achieved much later--during the 1200 and 1400 EST hours. The largest [O₃]_{max}, 0.13 ppm, was achieved at the target HC/NO_x ratio of 10, and as the initial ratio was moved away from 10, maximum ozone concentrations decreased. Except for the position of the methyl group, 2-methylthiophene and 3-methylthiophene are identical; however, the largest [O₃]_{max} for the 2-methylthiophene experiments amounted to only one-third of the corresponding value for the 3-methylthiophene experiments. Thus, the position of the methyl group significantly affected the reactivity of methylthiophene as indicated by ozone generation.

In contrast to thiophene, which produced small concentrations of PAN, 2-methylthiophene as well as 3-methylthiophene and 2,5-dimethylthiophene produced significant amounts of PAN. Although small quantities of MN were detected during the 2-methylthiophene experiments, appreciable concentrations of MN and EN were not found. Maximum concentrations of PAN were dependent on the initial conditions. The largest [PAN]_{max} occurred at the target HC/NO_x ratio of 10, and as the initial ratio was moved away from 10, maximum PAN concentrations decreased. Thus, the ordering of the maximum PAN concentrations with respect to the initial HC/NO_x ratio was similar to that of the maximum ozone concentrations. In addition, PAN maxima in 3 of 4 cases occurred during the 1300 EST hour.

A nitrogen mass balance was estimated for each experiment based on chemiluminescent NO_x concentrations determined initially and again during the 1700 EST hour of the first day. For the 2-methylthiophene-NO_x experiments the fraction of initial NO_x that could be accounted for ranged from 0.21 to 0.60. The nitrogen balances were similar to those for the propene-NO_x experiments--in general the nitrogen balances were the poorest for those conditions where the highest ozone concentrations were generated. At the 1700 EST hour, 0.21 of the original NO_x could be accounted for at the target HC/NO_x ratio of 10. The accountable fraction increased as the target HC/NO_x ratios were moved away from 10. The unaccountable product nitrogen may be nitric acid or other undetermined nitrogen-containing species. The fate of NO_x in photochemically reacting systems is largely unknown.

The test species, 2-methylthiophene, was consumed at moderate rates during these experiments. Its concentration could be approximated by the difference between the total sulfur and the SO_2 concentrations. Estimates were made of the fraction of initially present $\text{C}_5\text{H}_6\text{S}$ that remained unreacted at the 1200 EST hour of the first day. For the 4 experiments the fraction of initial $\text{C}_5\text{H}_6\text{S}$ that could be accounted for ranged from 0.44 to 0.55. The fraction of unreacted reactant was the smallest at the target HC/NO_x ratio of 4 and increased as this ratio was moved away from 4. Inspection of the times to one-half consumption of 2-methylthiophene also indicates that the $\text{C}_5\text{H}_6\text{S}$ disappearance rate was dependent on the initial HC/NO_x ratio. Generally, the disappearance rate was faster at the target HC/NO_x ratios of 4 and 10 than at 2 or 20.

Sulfur dioxide was found as a product of the photooxidation of 2-methylthiophene in the presence of NO_x in each of the 4 experiments. Maximum concentrations and their times of occurrence were dependent on the initial HC/NO_x ratio. Sulfur dioxide maxima ranged from trace quantities to 0.09 ppm. A maximum concentration was first achieved at the target HC/NO_x ratio of 10; whereas, at target ratios of 2 and 4 the SO_2 maxima occurred later--during the 1600 EST hour. The largest $[\text{SO}_2]_{\text{max}}$ was 0.09 ppm and also occurred at the target HC/NO_x ratio of 10. As the target ratio was moved away from 10, maximum SO_2 concentrations decreased. Maximum concentrations of other reaction products such as ozone and PAN exhibited behavior that was similarly associated with initial HC/NO_x ratios.

Moderate quantities of condensation nuclei were produced on the first day. Maximum concentrations ranged from 26000 to 33500 cm^{-3} and occurred during the 0700 EST hour. Although the CN maxima were not appreciably different, the largest maximum CN concentration occurred at the target HC/NO_x ratio of 2, and maximum CN concentrations generally decreased with increasing HC/NO_x ratios.

Maximum TPS concentrations were dependent on the initial HC/NO_x ratio. Conversion of 2-methylthiophene to particulate sulfur was rapid with maximum TPS concentrations occurring during the 1100 EST hour in 3 of 4 cases. Only a small portion of the reacted test species was detected as particulate

sulfur. Maximum TPS concentrations were not appreciably different and ranged from 22 to 29 $\mu\text{g}/\text{m}^3$ or the equivalent of 0.017 to 0.022 ppmS. As with O_3 , PAN, and SO_2 maxima, the largest maximum TPS concentration, 29 $\mu\text{g}/\text{m}^3$, occurred at the target HC/NO_x ratio of 10, and the TPS maxima decreased as the target ratios were moved away from 4.

The ratio of product sulfur as particulate to the total accountable reacted sulfur ($[\text{TPS}]$ plus $[\text{SO}_2]$) was determined for 3 of the 4 experiments. This ratio was based on data collected during or interpolated for the hour of occurrence of the maximum SO_2 concentration, and it permits an assessment of the distribution of accountable product sulfur between the gas and particulate phases. For the 2-methylthiophene- NO_x system this ratio was small, ranging from 0.13 to 0.15. Differences in these ratios were not considered to be significant among the 3 experiments under consideration. Thus, this ratio displayed no apparent trends with initial conditions. These results do suggest, however, that approximately 85 percent of the accountable product sulfur existed as SO_2 . In addition, results in the appendix suggest that a substantial portion of the product sulfur cannot be accounted for.

The second day, 31 October, was partly cloudy with 49 percent sunshine and a cumulative daily solar radiation of 243 cal cm^{-2} . Second-day maximum TPS and CN concentrations were low. Second-day maximum TPS concentrations ranged from 0 to 14 $\mu\text{g}/\text{m}^3$ or 0 to 0.011 ppmS. The largest second-day $[\text{TPS}]_{\text{max}}$ occurred at the target HC/NO_x ratio of 2, and the second-day maxima decreased with increasing initial ratios. Second-day CN maxima ranged from 3600 to 13500 cm^{-3} . The largest second-day CN maximum concentration occurred at the target HC/NO_x ratio of 10, and the second-day CN maxima decreased as this ratio was moved away from 10. Although only nonquantifiable trace amounts of SO_2 were found, SO_2 was produced on the second day. Second-day maximum and net ozone concentrations exceeded the first-day maxima at target HC/NO_x ratios of 2 and 4. Net ozone concentrations ranged from 0.007 to 0.120 ppm. The largest net ozone concentration, 0.120 ppm, was achieved at the target HC/NO_x ratio of 4, rather than 10, where the largest first-day maximum ozone concentration had occurred. Thus, more initial NO_x was required to generate the largest second-day ozone concentration than was required to generate the largest first-day concentration. This behavior is similar to

that for the experiments conducted with thiophene and for those with the 2,5-dimethylthiophene.

3-Methylthiophene

Mixtures of 3-methylthiophene and NO_x were irradiated on 22 and 23 October, and an additional experiment was conducted on 18 and 19 November 1977. In general, only the October experiments are considered in the current discussion. On 22 October the cumulative daily solar radiation was 366 cal cm^{-2} with 100 percent of the possible minutes of direct sunshine and a maximum temperature of 23.9° C . Selected results from the October 3-methylthiophene- NO_x experiments are summarized in Table 32. Concentration-time profiles of various reactants and products for the 22 October experiment conducted in Chamber No. 3 are presented in Figure 25.

The photochemical behavior of irradiated mixtures of NO_x and 3-methylthiophene was similar in various respects to that of irradiated mixtures of NO_x and hydrocarbons such as propene. In each of the 3-methylthiophene- NO_x experiments conversion of NO to NO_2 was rapid. The time of occurrence of NO- NO_2 crossover was dependent on the initial HC/ NO_x ratio--the duration of irradiation required to achieve crossover increased with decreasing initial HC/ NO_x ratios. Crossover was first achieved at the target HC/ NO_x ratio of 20. For the 4 experiments crossover occurred between 0907 and 1030 EST, requiring 2.7 to 4.0 hours of irradiation. The timing of the maximum NO_2 concentration was also dependent on the initial HC/ NO_x ratio and generally occurred within the hour following crossover. The timing of both NO- NO_2 crossover and maximum NO_2 concentration with respect to initial HC/ NO_x ratios for the 3-methylthiophene experiments was almost identical to that for the 2,5-dimethylthiophene experiments.

Ozone accumulated during each experiment. Maximum concentrations and their times of occurrence were dependent on the initial HC/ NO_x ratio. Ozone maxima ranged from 0.05 to 0.37 ppm. A maximum ozone concentration was first achieved at the target HC/ NO_x ratio of 20 during the 1000 EST hour. At the lower ratios ozone maxima were achieved much later--during the 1400 and 1500 EST hours. The largest $[\text{O}_3]_{\text{max}}$, 0.37 ppm, was achieved at the target HC/ NO_x ratio of 4, and as the initial ratio was moved away from 4, maximum ozone concentrations decreased. In addition, 3-methylthiophene

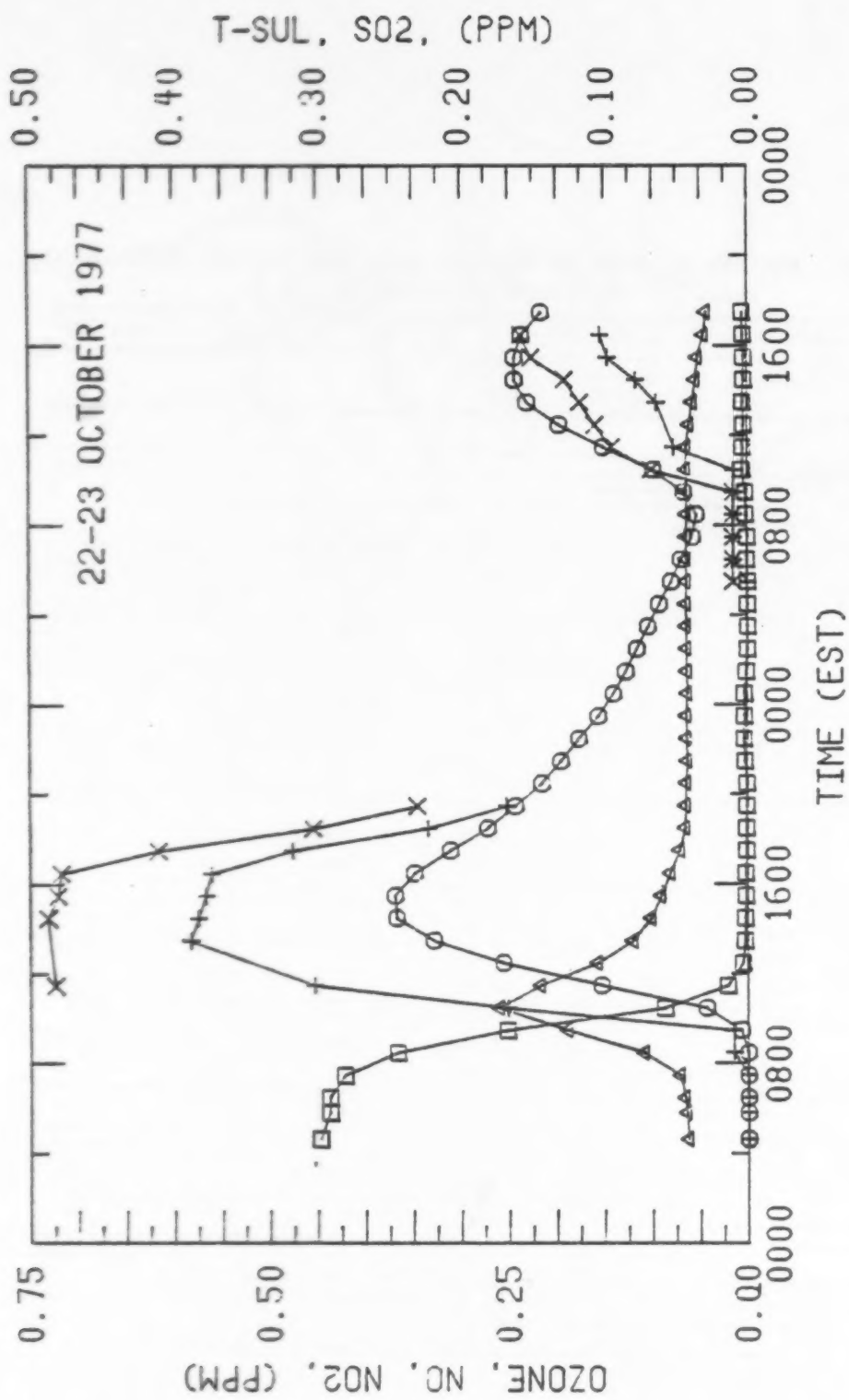


Figure 25. Concentration-time profiles of various reactants and products for the 22 and 23 October 1977 3-methylthiophene-NO_x experiment conducted in RTI Chamber No. 3. Target initial conditions: 2.0 ppmC 3-methylthiophene and 0.5 ppm NO_x. Symbol key: (o) O₃; (□) NO; (Δ) NO₂; (x) Total Sulfur; and (+) SO₂.

TABLE 32. SUMMARY OF SELECTED RESULTS FROM SMOG CHAMBER EXPERIMENTS
CONDUCTED WITH 3-METHYLTHIOPHENE AND NO_x

TEST COMPOUND ^{a/}	DATE ^{b/}	T _{max} ^{c/}	%SS ^{d/}	CU-SR ^{e/}	SUNRISE ^{f/}
3-Methylthiophene	10-22-77	23.9	100	366	6.47
C ₅ H ₆ S	10-23-77	21.7	80	323	
SMOG CHAMBER NUMBER		4	3	2	1
FIRST DAY PARAMETERS					
Target Initial HC/NO _x (ppmC/ppm)		2	4	10	20
Time of NO-NO ₂ Crossover, ^{g/} (hrs EST)		10.50	9.74	9.46	9.13
[NO ₂] _{max} , ppm ^{h/}		0.462	0.260	0.086	0.027
Time of [NO ₂] _{max} , (hrs EST) ^{h/}		11.63	10.47	9.30	9.13
[O ₃] _{max} , ppm		0.054	0.369	0.197	0.077
Time of [O ₃] _{max} , (hrs EST)		14.63	15.47	15.30	10.13
[PAN] _{max} , ppm		0.008	0.028	0.017	0.010
Time of [PAN] _{max} , (hrs EST)		19.63	19.47	11.30	12.13
[MN] ppm ^{i/}		ND	ND	0.001	tr
[EN] ppm		0	0	0	0
[NO _x] _{initial} , ^{j/}		0.962	0.504	0.222	0.139
[NO _x] @ 1700 EST ^{j/}		0.390	0.073	0.043	0.028
fNO _x @ 1700 EST ^{j/}		0.405	0.145	0.194	0.201
fC ₅ H ₆ S @ 1200 EST ^{k/}		0.243	0.216	0.226	0.406
Time of [C ₅ H ₆ S] ₁ , (hrs EST) ^{k/}		10.78	10.46	10.20	10.92
[SO ₂] _{max} , ppm		0.350	0.389	0.321	0.293
Time of [SO ₂] _{max} , (hrs EST)		15.63	13.47	13.30	15.13
[TPS] _{max} , ^{l/} (ppmS)		29.2	57.0	28.9	16.0
Time of [TPS] _{max} , (hrs EST)		0.022	0.044	0.022	0.012
R ^{l/}		14.63	14.47	10.30	10.13
[CN] _{max} , cm ⁻³		0.04	0.08	0.05	0.03
Time of [CN] _{max} , (hrs EST)		24,000	22,000	16,000	16,000
Night-time O ₃ Half-Life (hrs) ^{m/}		7.63	7.47	7.30	7.13
		NA	7	5 ^{n/}	NA

(continued)

NOTES: Abbreviations: ND = no data are available; NA = not applicable;
0 = not detected; tr = detected, but not quantified; X = concentration decreased, no maximum observed.

The appendix should be consulted for additional data that are not summarized in this table.

TABLE 32. (continued)

SMOG CHAMBER NUMBER	4	3	2	1
SECOND DAY PARAMETERS				
$[O_3]_{\max}$, ppm	0.094	0.243	0.181	0.106
ΔO_3 , ppm ^{a/}	0.094	0.189	0.158	0.106
$[SO_2]_{\max}$, ppm	0.136	0.103	0.071	0.136
ΔSO_2 , ppm ^{a/}	0.136	0.103	0.071	0.136
$[TPS]_{\max}$, $\mu\text{g}/\text{m}^3$	8.4	6.0	3.5	3.9
(ppmS)	0.006	0.005	0.003	0.003
$[CN]_{\max}$, cm^{-3}	5,000	3,400	2,400	1,800

a/ Target initial concentration 2.0 ppmC, 0.4 ppm (V/V), or 0.4 ppmS.

b/ Dates of first and second days of the experiment.

c/ Daily maximum temperature in °C.²⁹

d/ Duration of direct solar radiation reported as percent of possible minutes of sunshine.²⁹

e/ Cumulative daily solar radiation expressed in Langley (cal cm⁻²); note that the second-day value is the cumulative solar radiation on that day until the experiment was terminated--usually 1700 EST.

f/ Time of sunrise in hours (EST); since the times of sunrise are approximately the same for both days, the time is given for the first day only.

g/ Daily median concentrations of species tentatively identified to be methyl and ethyl nitrate; they are not listed in the appendix.

h/ The initial $[NO_x]$ is taken to be the concentration that existed at approximately the time of sunrise^x; the table entry has NOT been corrected for possible interferences.

i/ Fraction of initial NO_x remaining at the 1700 EST hour calculated from NO_x concentrations as determined by^x the chemiluminescent NO_x analyzer.

j/ Fraction of accountable test compound at the 1200 EST hour.

k/ Estimate of the time at which approximately one-half of the test compound was consumed.

l/ Ratio of product sulfur as particulate to the total accountable reacted sulfur at the time of $[SO_2]_{\max}$: $([TPS]/([TPS]+[SO_2]))$.

m/ Estimate of ozone half-life based on data collected during the 2000 EST hour of the first day and the 0400 EST hour of the second day: $t_{1/2} \cong 5.545/\ln ([O_3]_{2000}/[O_3]_{0400})$.

n/ This half-life may be suspect, since ozone concentrations smaller than 0.1 ppm were involved in its determination.

o/ Net concentration on the second day is the difference between the second-day maximum concentration and the preceding minimum concentration: $\Delta O_3 = [O_3]_{\max} - [O_3]_{\min}$ and $\Delta SO_2 = [SO_2]_{\max} - [SO_2]_{\min}$.

p/ Since 3-Methylthiophene acted as a strong interferent with the chemiluminescent determination of nitrogen oxides, parameters based on NO_x data are uncertain.

produced the largest maximum ozone concentration among the four tested thiophenes and thus had the largest ozone-generative potential.

In contrast to thiophene, which produced small concentrations of PAN, 3-methylthiophene, as well as 2-methylthiophene and 2,5-dimethylthiophene, produced significant amounts of PAN. Although small quantities of MN were detected during the 3-methylthiophene experiments, appreciable concentrations of MN and EN were not found. Maximum concentrations of PAN were dependent on the initial conditions. The largest $[PAN]_{max}$ occurred at the target HC/NO_x ratio of 4, with the remaining maxima decreasing as this ratio was moved away from 4. Thus, the ordering of the maximum PAN concentrations with respect to the initial HC/NO_x ratio was similar to that of the maximum ozone concentrations. Missing data prevent an evaluation of timing of the maximum PAN concentrations (see appendix).

Inspection of the first-day NO_x data in the appendix revealed unusual behavior. Inflections in the NO_x concentration-time profiles occurred in the experiments conducted at the two highest initial HC/NO_x ratios. The timing of these inflections coincided with the initial buildup of PAN that occurred during the 1000 and 1100 EST hours. This behavior was not observed at lower HC/NO_x ratios, although it may have been obscured by the higher NO_x concentrations employed in these experiments. Similar behavior has been noted previously in the current study and has been tentatively attributed to unknown transient nitrogen-containing species. In the previously noted cases the unusual behavior was associated with the presence of an ethyl group in the test species. The photooxidation of 3-methylthiophene involves the formation of radicals that contain ethyl groups as evidenced by PAN formation. However, an additional factor which complicates these findings was the discovery that 3-methylthiophene interferes strongly with chemiluminescent NO and NO₂ measurements (see Table 13). This interference introduces uncertainty into all the tabulated parameters that involved chemiluminescent NO_x measurements. At low initial NO_x concentrations (i.e., high HC/NO_x ratios) and early in the experiment when the 3-methylthiophene concentration was high, the relative impact of the interference was the largest. Since the NO_x concentration data cannot be corrected for the observed interference, the cause of the unusual NO_x behavior cannot be resolved at this time.

A nitrogen mass balance was estimated for each experiment based on chemiluminescent NO_x concentrations determined initially and again during the 1700 EST hour of the first day. For the 3-methylthiophene- NO_x experiments, the fraction of initial NO_x that could be accounted for ranged from 0.15 to 0.41. The nitrogen balances were similar to those for the propene- NO_x experiments--in general the balances were the poorest for those conditions where the highest ozone concentrations were generated. At the 1700 EST hour, 0.15 of the original NO_x could be accounted for at the target HC/NO_x ratio of 4. The accountable fraction increased as the target ratios were moved away from 4. The unaccountable product nitrogen may be nitric acid or other undetermined nitrogen-containing species. The fate of NO_x in photochemically reacting systems is largely unknown.

The test species, 3-methylthiophene, was consumed rapidly during these experiments. Its concentration could be approximated by the difference between the total sulfur and the SO_2 concentrations. Estimates were made of the fraction of initially present $\text{C}_5\text{H}_6\text{S}$ that remained unreacted at the 1200 EST hour of the first day. For the four experiments the fraction of initial $\text{C}_5\text{H}_6\text{S}$ that could be accounted for ranged from 0.22 to 0.41. The ordering of the accountable fractions of $\text{C}_5\text{H}_6\text{S}$ was similar to that observed earlier for the fractions of NO_x remaining at the 1700 EST hour. In both cases the fractions of unreacted reactant were the smallest at the target HC/NO_x ratio of 4 and increased as the target ratios were moved away from 4. Inspection of the times to one-half consumption of 3-methylthiophene also indicates that the $\text{C}_5\text{H}_6\text{S}$ disappearance rate was dependent on the initial HC/NO_x ratio. Generally, the disappearance rate was faster at the target HC/NO_x ratios of 4 and 10 than at 2 or 20.

Sulfur dioxide was found as a product of the photooxidation of 3-methylthiophene in the presence of NO_x in each of the four experiments. Maximum concentrations and their times of occurrence were dependent on the initial HC/NO_x ratio. Sulfur dioxide maxima ranged from 0.29 to 0.39 ppm. Maximum concentrations were first achieved during the 1300 EST hour at target HC/NO_x ratios of 4 and 10, and at ratios 2 and 20 $[\text{SO}_2]_{\text{max}}$ occurred during the 1500 EST hour. This behavior is consistent with that of the 3-methylthiophene disappearance rates noted earlier. The largest $[\text{SO}_2]_{\text{max}}$ was 0.39 ppm and

occurred at the target HC/NO_x ratio of 4. As the target ratio was moved away from 4, maximum SO_2 concentrations decreased. Maximum concentrations of other reaction products such as ozone and PAN exhibited behavior that was similarly associated with initial HC/NO_x ratios.

Moderate quantities of condensation nuclei were produced on the first day. Maximum concentrations ranged from 16000 to 24000 cm^{-3} and occurred during the 0700 EST hour. The largest maximum CN concentration occurred at the target HC/NO_x ratio of 2, and maximum CN concentrations decreased with increasing HC/NO_x ratios.

Maximum TPS concentrations and their times of occurrence were dependent on the initial HC/NO_x ratio. In the experiments conducted at target ratios of 10 and 20, $[\text{TPS}]_{\text{max}}$ were achieved during the 1000 EST hour; however, at target ratios of 2 and 4 $[\text{TPS}]_{\text{max}}$ occurred during the 1400 EST hour. Only a small portion of the reacted test species was detected as particulate sulfur, and maximum TPS concentrations ranged from 16 to 57 $\mu\text{g}/\text{m}^3$ or the equivalent of 0.012 to 0.044 ppmS. As with O_3 , PAN, and SO_2 maxima, the largest maximum TPS concentration occurred at the target HC/NO_x ratio of 4, and the TPS maxima decreased as the target ratios were moved away from 4.

The ratio of product sulfur as particulate to the total accountable reacted sulfur ($[\text{TPS}]$ plus $[\text{SO}_2]$) was determined for each experiment. This ratio was based on data collected during or interpolated for the hour of occurrence of the maximum SO_2 concentration, and it permits an assessment of the distribution of accountable product sulfur between the gas and particulate phases. For the 3-methylthiophene- NO_x system this ratio was small, ranging from 0.03 to 0.08. The largest ratio, 0.08, occurred at the target HC/NO_x ratio of 4 and decreased as the target HC/NO_x ratio was moved away from 4. Other tabulated parameters also indicated that the reactivity of the 3-methylthiophene- NO_x system was large at the target HC/NO_x ratio of 4. Thus, although most of the accountable product sulfur existed as SO_2 , particulate sulfur comprised increasing proportions of accountable product sulfur as the reactivity of the system was increased. In addition, results in the appendix suggest that a substantial portion of the product sulfur cannot be accounted for.

The second day, 23 October, was sunny with 80 percent sunshine and a cumulative daily solar radiation of 323 cal cm^{-2} . Second-day maximum TPS

and CN concentrations were low. Second-day maximum TPS concentrations ranged from 3.5 to 8.1 $\mu\text{g}/\text{m}^3$ or 0.003 to 0.006 ppmS and generally decreased with increasing initial HC/NO_x ratios. Second-day CN maxima ranged from 1800 to 5000 cm^{-3} and also decreased with increasing initial HC/NO_x ratios. Second-day maximum and net SO₂ concentrations, although substantial, did not exceed the first-day maxima. Since the SO₂ concentrations decayed to non-quantifiable trace amounts during the evening and night of the first day, second-day maximum and net concentrations were identical. These values ranged from 0.07 to 0.14 ppm. The highest concentrations occurred at target HC/NO_x ratios of 2 and 20, the two experiments where the first-day consumption of 3-methylthiophene had been the least complete. In addition to an increase in SO₂ concentration, the total sulfur concentration also increased on the second day. This also occurred in the experiments conducted with 2,5-dimethylthiophene. This behavior suggests that a sulfur-containing species was sorbed by the chamber walls on the evening of the first day and was subsequently released during the second day. The identity of the responsible sulfur species is unknown. There is some evidence to suggest that SO₂ can be deposited on and released in small amounts from the chamber walls (see the section on Characterization Experiments). It is possible that the sulfur compound was SO₂, an intermediate product, unreacted reactant, or some combination of these species. Second-day maximum and net ozone concentrations exceeded the first-day maxima at target HC/NO_x ratios of 2 and 20. The net ozone concentrations ranged from 0.09 to 0.19 ppm. As with the first-day ozone maxima, the largest net ozone concentration occurred at the target HC/NO_x ratio of 4, and the net concentrations decreased as the initial HC/NO_x ratio was moved away from 4.

2,5-Dimethylthiophene

Mixtures of 2,5-dimethylthiophene and NO_x were irradiated on 20 and 21 October, and an additional experiment was conducted on 18 and 19 November 1977. In general, only the October experiments are considered in the current discussion. On 20 October the cumulative daily solar radiation was 386 cal cm^{-2} with 100 percent of the possible minutes of direct sunshine and a maximum temperature of 18.9° C. Selected results from the October C₆H₈S-NO_x experiments are summarized in Table 33. Concentration-time profiles of

TABLE 33. SUMMARY OF SELECTED RESULTS FROM SMOG CHAMBER EXPERIMENTS
CONDUCTED WITH 2,5-DIMETHYLTHIOPHENE AND NO_x

TEST COMPOUND ^{a/}	DATE ^{b/}	T _{max} ^{c/}	%SS ^{d/}	CU-SR ^{e/}	SUNRISE ^{f/}
2,5-Dimethylthiophene	10-20-77	18.9	100	386	6.43
C ₆ H ₄ S	10-21-77	19.4	85	347	
SMOG CHAMBER NUMBER		3	4	1	2
FIRST DAY PARAMETERS					
Target Initial HC/NO _x (ppmC/ppm)		2	4	10	20
Time of NO-NO ₂ Crossover, (hrs EST)		10.23	9.72	9.29	9.35
[NO ₂] _{max} , ppm		0.535	0.267	0.084	0.037
Time of [NO ₂] _{max} , (hrs EST)		11.47	10.63	10.13	9.30
[O ₃] _{max} , ppm		0.144	0.252	0.108	0.079
Time of [O ₃] _{max} , (hrs EST)		15.47	13.63	11.13	11.30
[PAN] _{max} , ppm		0.042	0.058	0.024	0.012
Time of [PAN] _{max} , (hrs EST)		19.47	19.63	12.13	14.30
[MN] ppm ^{g/}		0.007	0.009	0.001	tr
[EN] ppm		0	tr	0	0
[NO _x] _{initial} ^{h/}		1.032	0.500	0.184	0.097
[NO _x] @ 1700 EST		0.288	0.134	0.047	0.033
ENO _x @ 1700 EST ^{i/}		0.279	0.268	0.255	0.340
fC ₆ H ₄ S @ 1200 EST ^{j/}		0.236	0.287	0.516	0.703
Time of [C ₆ H ₄ S] _k , (hrs EST) ^{k/}		10.76	11.28	12.41	18.30
[SO ₂] _{max} , ppm		0.444	0.415	0.223	0.192
Time of [SO ₂] _{max} , (hrs EST)		14.47	14.63	15.13	16.30
[TPS] _{max} , µg/m ³		34.8	25.0	5.7	3.3
(ppmS)		0.027	0.019	0.004	0.003
Time of [TPS] _{max} , (hrs EST)		12.47	12.63	10.13	12.30
R ^{l/}		0.05	0.04	0.01	0
[CN] _{max} , cm ⁻³		31,000	25,000	13,500	5,700
Time of [CN] _{max} , (hrs EST)		12.47	9.63	13.13	12.30
Night-time O ₃ Half-Life (hrs) ^{m/}		2 ^{n/}	6 ^{n/}	2 ^{n/}	2 ^{n/}

(continued)

NOTES: Abbreviations: ND = no data are available; NA = not applicable;
0 = not detected; tr = detected, but not quantified; X = concentration decreased, no maximum observed.

The appendix should be consulted for additional data that are not summarized in this table.

TABLE 33. (continued)

SMOG CHAMBER NUMBER	3	4	1	2
SECOND DAY PARAMETERS				
$[O_3]_{\max}$, ppm	0.283	0.248	0.048	0.042
ΔO_3 , ppm ^{a/}	0.283	0.211	0.048	0.042
$[SO_2]_{\max}$, ppm	0.120	0.068	0.116	0.112
ΔSO_2 , ppm ^{a/}	0.120	0.068	0.116	0.112
$[TPS]_{\max}$, $\mu\text{g}/\text{m}^3$	3.6	4.4	0	0
(ppmS)	0.003	0.003	0	0
$[CN]_{\max}$, cm^{-3}	2,400	2,900	5,700	5,000

^{a/} Target initial concentration 2.0 ppmC, 0.33 ppm (V/V), or 0.33 ppmS.

^{b/} Dates of first and second days of the experiment.

^{c/} Daily maximum temperature in °C.²⁹

^{d/} Duration of direct solar radiation reported as percent of possible minutes of sunshine.²⁹

^{e/} Cumulative daily solar radiation expressed in Langleys (cal cm^{-2}); note that the second-day value is the cumulative solar radiation on that day until the experiment was terminated--usually 1700 EST.

^{f/} Time of sunrise in hours (EST); since the times of sunrise are approximately the same for both days, the time is given for the first day only.

^{g/} Daily median concentrations of species tentatively identified to be methyl and ethyl nitrate; they are not listed in the appendix.

^{h/} The initial $[NO_x]$ is taken to be the concentration that existed at approximately the time of sunrise; the table entry has NOT been corrected for possible interferences.

^{i/} Fraction of initial NO_x remaining at the 1700 EST hour calculated from NO_x concentrations as determined by^x the chemiluminescent NO_x analyzer.

^{j/} Fraction of accountable test compound at the 1200 EST hour.

^{k/} Estimate of the time at which approximately one-half of the test compound was consumed.

^{l/} Ratio of product sulfur as particulate to the total accountable reacted sulfur at the time of $[SO_2]_{\max}$: $(([TPS]/([TPS]+[SO_2])))$.

^{m/} Estimate of ozone half-life based on data collected during the 2000 EST hour of the first day and the 0400 EST hour of the second day: $t_{1/2} = 5.545/\ln([O_3]_{2000}/[O_3]_{0400})$.

^{n/} This half-life may be suspect, since ozone concentrations smaller than 0.1 ppm were involved in its determination.

^{o/} Net concentration on the second day is the difference between the second-day maximum concentration and the preceding minimum concentration: $\Delta O_3 = [O_3]_{\max} - [O_3]_{\min}$ and $\Delta SO_2 = [SO_2]_{\max} - [SO_2]_{\min}$.

various reactants and products for the 20 October experiment conducted in Chamber No. 4 are presented in Figure 26.

The photochemical behavior of irradiated mixtures of NO_x and $\text{C}_6\text{H}_5\text{S}$ was similar in various respects to that of irradiated mixtures of NO_x and hydrocarbons such as propene. In each of the $\text{C}_6\text{H}_5\text{S}-\text{NO}_x$ experiments, conversion of NO to NO_2 was rapid. The time of occurrence of $\text{NO}-\text{NO}_2$ crossover was dependent on the initial HC/NO_x ratio. With a single exception, the duration of irradiation required to achieve $\text{NO}-\text{NO}_2$ crossover increased with decreasing HC/NO_x ratios. Crossover was first achieved at the target HC/NO_x ratio of 10, although the time of occurrence was not appreciably different from that at the target ratio of 20. For the 4 experiments crossover occurred between 0917 and 1013 EST, requiring 2.9 to 3.8 hours of irradiation. The timing of the maximum NO_2 concentration was also dependent on the initial HC/NO_x ratio and generally occurred within the hour following $\text{NO}-\text{NO}_2$ crossover.

Ozone accumulated during each experiment. Maximum concentrations and their times of occurrence were dependent on the initial HC/NO_x ratio. Ozone maxima ranged from 0.08 to 0.25 ppm. Maximum ozone concentrations occurred first at the target HC/NO_x ratios of 10 and 20, and these maxima were achieved during the 1100 EST hour. As the initial HC/NO_x ratio was decreased, ozone maxima occurred later in the day. The largest $[\text{O}_3]_{\text{max}}$, 0.25 ppm, occurred at the target HC/NO_x ratio of 4, and as the target ratio was moved away from 4, maximum ozone concentrations decreased.

In contrast to thiophene, which produced small concentrations of PAN, 2,5-dimethylthiophene, as well as 2-methylthiophene and 3-methylthiophene, produced significant amounts of PAN. Among the thiophenes, however, only 2,5-dimethylthiophene produced appreciable amounts of MN. In addition, none of the thiophenes produced appreciable amounts of EN. For the 2,5-dimethylthiophene experiments both PAN and MN concentrations displayed similar trends with initial conditions. The largest maximum concentrations of these species occurred at the target HC/NO_x ratio of 4 with the remaining maxima decreasing as this ratio was moved away from 4. Thus, the ordering of the maximum PAN concentrations with respect to the initial HC/NO_x ratio was similar to that of the maximum ozone concentrations. In addition, the timing of the maximum PAN concentrations also paralleled that of ozone maxima--occurring later in the day as the initial HC/NO_x ratio was decreased.

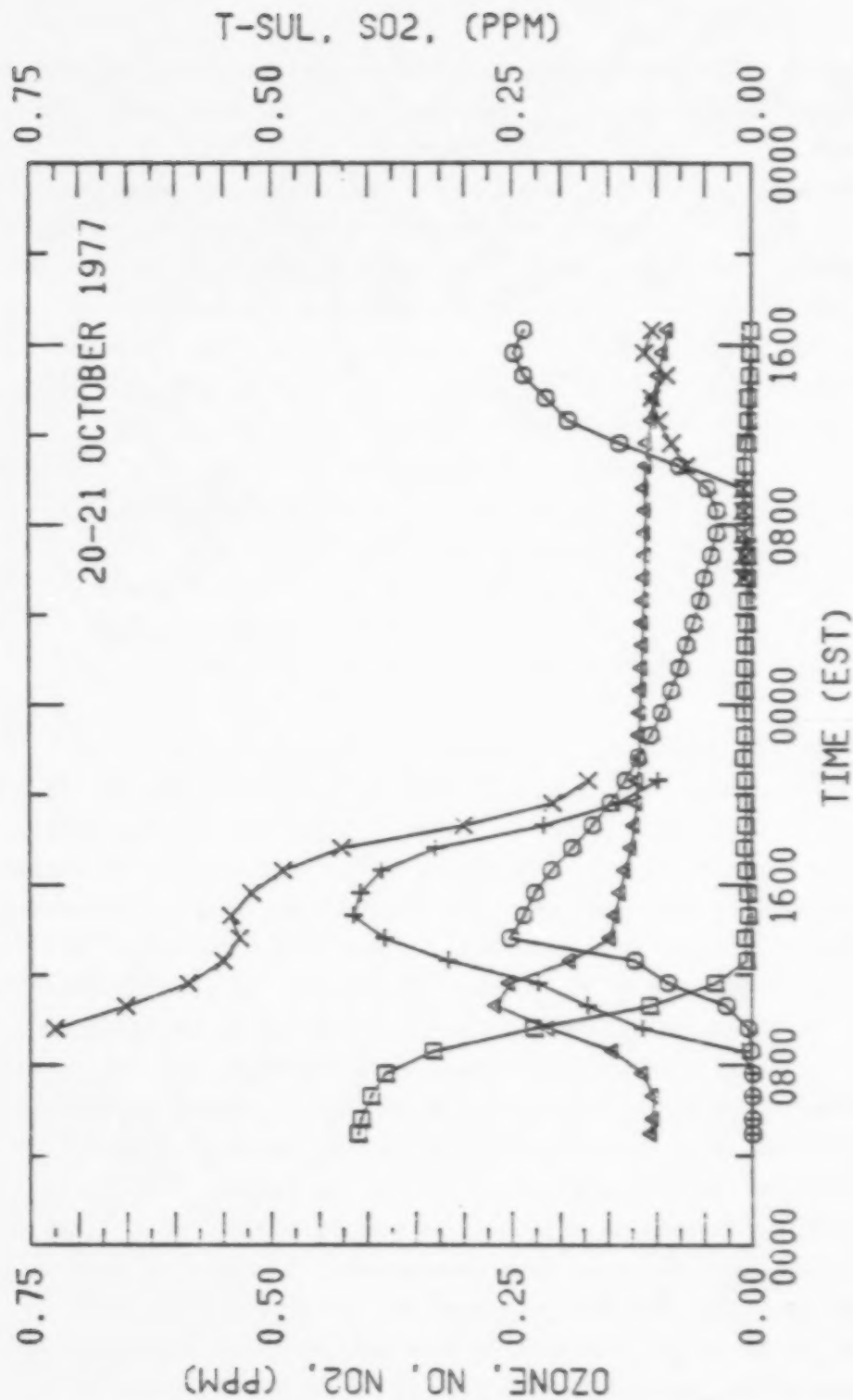


Figure 26. Concentration-time profiles of various reactants and products for the 20 and 21 October 1977 2,5-dimethylthiophene-NO_x experiment conducted in RTI Chamber No. 4. Target initial conditions: 2.0 ppmC 2,5-dimethylthiophene and 0.5 ppm NO_x. Symbol key: (o) O₃; (□) NO; (Δ) NO₂; (x) Total Sulfur; and (+) SO₂.

The identification of PAN and the tentative identification of MN will provide clues that may permit elucidation of the chemistry of the 2,5-dimethylthiophene- NO_x system.

A nitrogen mass balance was estimated for each experiment based on chemiluminescent NO_x concentrations determined initially and again during the 1700 EST hour of the first day. For the four $\text{C}_6\text{H}_8\text{S}-\text{NO}_x$ experiments the fraction of initial NO_x that could be accounted for ranged from 0.26 to 0.34. At the 1700 EST hour, 0.26 of the original NO_x could be accounted for at the target HC/NO_x ratio of 10. The accountable fraction increased as the target ratios were moved away from 10. At target ratios of 2, 4, and 10, however, the fractions of accountable nitrogen were not appreciably different. The narrow spread for the nitrogen balances among the 4 experiments with 2,5-dimethylthiophene was in contrast to the large ranges estimated for the remaining three thiophenes that were tested. The unaccountable product nitrogen may be nitric acid, or other undetermined nitrogen-containing species. The fate of NO_x in photochemically reacting systems is largely unknown.

The test species, $\text{C}_6\text{H}_8\text{S}$, was consumed at a moderate-to-rapid rate during these experiments. Its concentration could be approximated by the difference between the total sulfur and the SO_2 concentrations. Estimates were made of the fraction of initially present $\text{C}_6\text{H}_8\text{S}$ that remained unreacted at the 1200 EST hour of the first day. For the four experiments the fraction of initial $\text{C}_6\text{H}_8\text{S}$ that could be accounted for ranged from 0.24 to 0.70 and was dependent on the initial HC/NO_x ratio. The fraction of accountable $\text{C}_6\text{H}_8\text{S}$ increase with increasing HC/NO_x ratios. Inspection of the times to one-half consumption of 2,5-Dimethylthiophene also indicates that the $\text{C}_6\text{H}_8\text{S}$ reaction rate was dependent on the initial HC/NO_x ratio. The disappearance rate of $\text{C}_6\text{H}_8\text{S}$ was the most rapid at the target HC/NO_x ratio of 2, and it became less rapid as the initial HC/NO_x ratio was increased.

Sulfur dioxide was found as a product of the photooxidation of $\text{C}_6\text{H}_8\text{S}$ in the presence of NO_x in each of the four experiments. Maximum concentrations and their times of occurrence were dependent on the initial HC/NO_x ratio. Sulfur dioxide maxima ranged from 0.19 to 0.44 ppm. Maximum concentrations were first achieved during the 1400 EST hour at target HC/NO_x ratios of 2

and 4, while at ratios of 10 and 20 $[\text{SO}_2]_{\text{max}}$ occurred during the 1500 and 1600 EST hours. This behavior is consistent with that of the $\text{C}_6\text{H}_5\text{S}$ disappearance rates noted earlier. The largest $[\text{SO}_2]_{\text{max}}$ was 0.44 ppm and occurred at the target HC/NO_x ratio of 2. As the initial HC/NO_x ratio increased, maximum SO_2 concentrations decreased. In addition, 2,5-dimethylthiophene produced the largest maximum SO_2 concentration observed among the four tested thiophenes.

Moderate quantities of condensation nuclei were produced on the first day, 20 October. Maximum concentrations ranged from 5700 to 31000 cm^{-3} and occurred between the 0900 and the 1300 EST hours. The largest maximum CN concentration occurred at the target HC/NO_x ratio of 2. The CN maxima decreased with increasing initial HC/NO_x ratios.

Maximum TPS concentrations were dependent on the initial HC/NO_x ratio. These maxima were achieved during the 1200 EST hour in 3 of 4 cases. Only a small portion of the reacted test species was detected as particulate sulfur. Maximum TPS concentrations ranged between 3 and 35 $\mu\text{g}/\text{m}^3$ or the equivalent of 0.003 to 0.027 ppmS. The ordering of the maximum TPS concentrations with respect to the initial HC/NO_x ratio was similar to that of the maximum SO_2 concentrations. The largest maximum TPS concentration occurred at the target HC/NO_x ratio of 2, and maximum TPS concentrations decreased with increasing initial HC/NO_x ratios (i.e., decreasing initial NO_x concentrations).

The ratio of product sulfur as particulate to the total accountable reacted sulfur ($[\text{TPS}]$ plus $[\text{SO}_2]$) was determined for each experiment. This ratio was based on data collected during or interpolated for the hour of occurrence of the maximum SO_2 concentration, and it permits an assessment of the distribution of accountable product sulfur between the gas and particulate phases. For the $\text{C}_6\text{H}_5\text{S}-\text{NO}_x$ system this ratio was small, ranging from 0 to 0.05. The largest ratio, 0.05, occurred at the target HC/NO_x ratio of 2 and decreased with increasing HC/NO_x ratios. Thus, although most of the accountable product sulfur existed as SO_2 , particulate sulfur comprised increasing proportions of accountable product sulfur at decreasing initial HC/NO_x ratios. In addition, results in the appendix suggest that a substantial portion of the product sulfur cannot be accounted for.

Second-day cumulative solar radiation values were high during both the October and November 2,5-dimethylthiophene- NO_x experiments. Maximum TPS concentrations on 21 October ranged from 0 to $4.4 \mu\text{g}/\text{m}^3$ or 0 to 0.003 ppmS. The largest second-day maximum TPS concentration was achieved at the target HC/NO_x ratio of 4. The results in the appendix also indicate that maximum CN concentrations were low on both 21 October and 19 November, ranging from 2400 to 5700 cm^{-3} . No apparent associations with initial conditions were noted for second-day maximum TPS and CN concentrations. Second-day maximum and net SO_2 concentrations, although substantial, did not exceed the first-day maxima. Since the SO_2 concentrations decayed to nonquantifiable trace amounts during the evening and night following the first day, second-day maximum and net concentrations were identical. These values ranged from 0.07 to 0.12 ppm and displayed no apparent trends with initial conditions. In addition to an increase in SO_2 concentration, the total sulfur concentration also increased on the second day. Similar behavior was noted in the experiments conducted with 3-methylthiophene. This behavior suggests that a sulfur-containing species was sorbed by the chamber walls on the evening of the first day and was subsequently released during the second day. The identity of the responsible sulfur species is unknown. There is some evidence to suggest that SO_2 can be deposited on and released in small amounts from the chamber walls (see the section on Characterization Experiments). It is possible that the sulfur compound was SO_2 , an intermediate product, unreacted reactant, or some combination of these species. Second-day maximum and net ozone concentrations exceeded the first-day maximum on 21 October at the target HC/NO_x ratio of 2 and on 19 November at the target ratio of 6.7. Second-day maxima as well as net ozone concentrations decreased with increasing initial HC/NO_x ratios (i.e., decreasing initial NO_x concentrations). For the four October experiments, net ozone concentrations ranged from 0.04 to 0.28 ppm. The largest net ozone concentration, 0.28 ppm, occurred at the target HC/NO_x ratio of 2, rather than 4, where the largest first-day maximum ozone concentration had occurred. Thus, more initial NO_x was required to generate the largest second-day ozone concentration than was required to generate the largest first-day concentration. This behavior is similar to that noted previously in the thiophene and 2-methylthiophene experiments.

COMPARISON OF CHEMICAL BEHAVIOR AMONG TEST SPECIES

In this analysis, selected aspects of the chemical behavior of the tested compounds are compared. Illustrations depicting the range of a single reaction parameter for each test species were prepared for several reaction parameters. Visual inspection of these illustrations permits a relative assessment among all tested compounds of the reaction parameters under consideration. It should be noted, however, that these comparisons are drawn from data collected on different days over the 3-month period from September through November of 1977. Thus, the reaction parameters under consideration are not from experiments conducted under identical environmental conditions. Seasonal and daily differences in such environmental variables as light intensity, sunlight duration, and temperature will influence the results considered in this portion of the analysis. The relative importance of these factors cannot be resolved at this time, and no attempt was made in this portion of the analysis to account for them. In spite of this complication, the current analysis should provide a rough basis for comparing the chemical behavior of the tested compounds.

Time to NO-NO₂ Crossover

In most cases, the photochemical behavior of irradiated mixtures of NO_x and individual test species was similar in various respects to that of irradiated mixtures of NO_x and hydrocarbons such as propene. Except for experiments conducted with H₂S and with COS, the presence of the test species resulted in more rapid conversion of NO to NO₂ than would have occurred in its absence. For each test compound, the range of hours of irradiation past sunrise required to achieve NO-NO₂ crossover is presented in Figure 27. For the thiols, organic sulfides, and organic disulfides, conversion from NO to NO₂ was extremely rapid and rather insensitive to initial conditions, as indicated by the narrow ranges of times. The organic disulfides displayed the most rapid conversion of NO to NO₂ of all the species tested in the current study. For carbon disulfide and thiophene, the times to crossover were highly sensitive to initial conditions and, in one case for thiophene, occurred on the second day. In addition, as methyl groups were added onto the thiophene molecule, the times to crossover became less sensitive to initial conditions. A seasonal influence on the times to crossover was

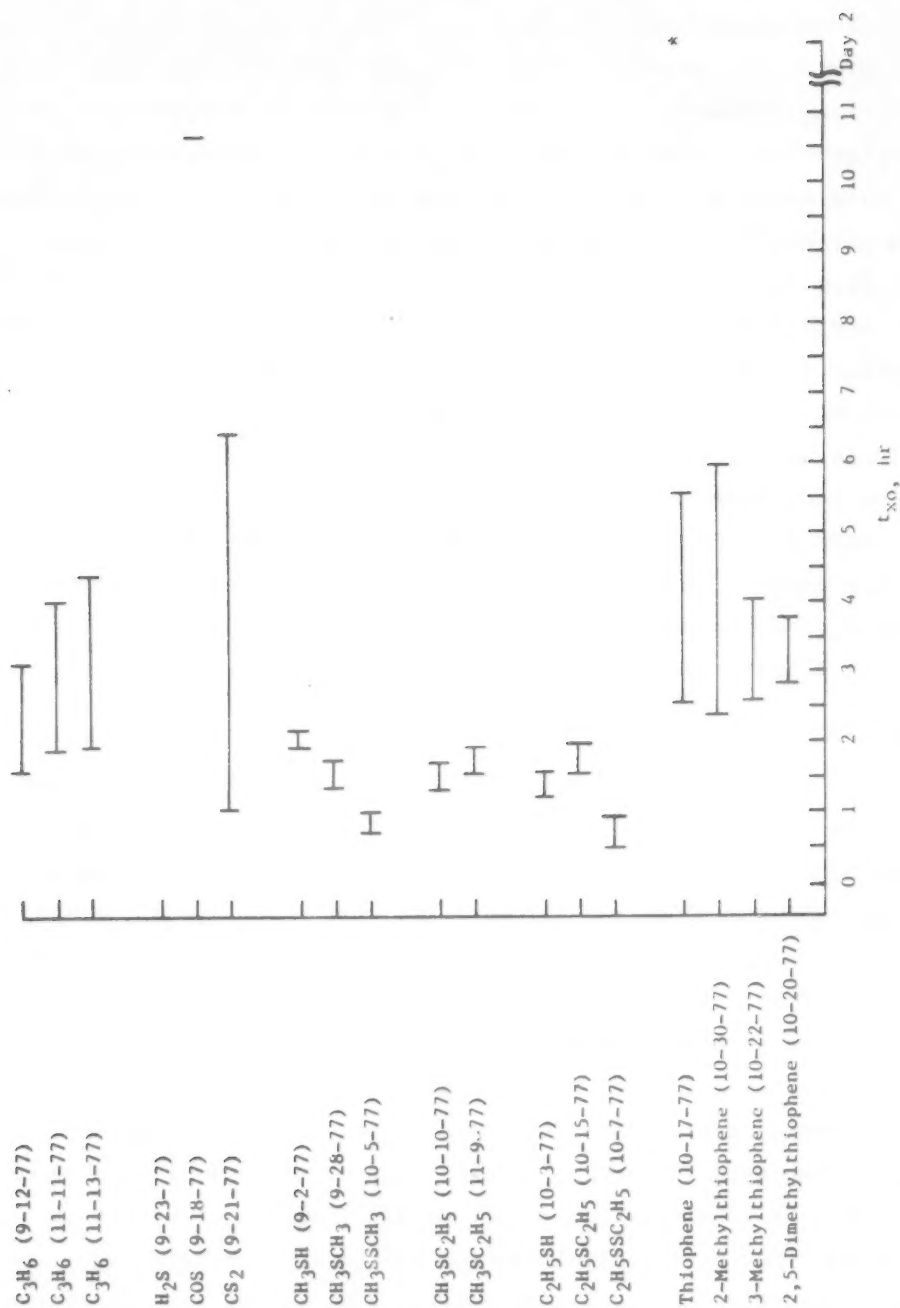


Figure 27. Range of the duration of irradiation (hours past sunrise) required on the first day to achieve $NO-NO_2$ crossover; * indicates that crossover occurred on the second day of irradiation.

exhibited in the propene-NO_x experiments. Slightly longer times were required in November, and they were more sensitive to initial conditions than they were in September. It is interesting to note that the 1-month separation in the two sets of CH₃SC₂H₅-NO_x experiments did not have a strong influence on times to crossover for these experiments.

Maximum First-Day Ozone Concentration

Except for the experiments conducted with H₂S and with COS, substantial amounts of ozone accumulated during at least one of the experiments conducted with each test compound. The range of maximum ozone concentrations found on the first day of the experiment is presented in Figure 28 for each test compound. As indicated by the relatively large ranges, the maximum ozone concentrations were rather sensitive to initial conditions. The largest [O₃]_{max} generated by tested sulfur species was generated by the CH₃SCH₃-NO_x system. Among the test species the thiols, organic sulfides, and organic disulfides had the largest ozone-production potential. In general, the thiophenes produced less ozone, although the addition of methyl groups onto the thiophene molecule enhanced its ozone production. On the first day of the experiments conducted with hydrogen sulfide and with carbonyl sulfide, very little NO was oxidized to NO₂, and essentially no ozone was produced. Carbon disulfide produced a substantial amount of ozone, but only at the highest initial HC/NO_x ratio. Strong seasonal influences on the maximum ozone concentrations were exhibited in the propene-NO_x experiments. Much larger ozone maxima were produced in September, and they were more sensitive to initial conditions than was found in November. In contrast, the 1-month separation in the two sets of CH₃SC₂H₅-NO_x experiments did not have a strong influence on maximum ozone concentrations observed in these two cases.

To explore the ozone generative potential of several of the tested compounds in more detail, graphical displays were prepared of maximum ozone concentrations produced at various target initial HC/NO_x ratios. These illustrations are presented in Figures 29, 30, and 31.

The thiols, organic sulfides, and organic disulfides produced high [O₃]_{max} at low initial HC/NO_x ratios. As indicated in Figure 29, the largest [O₃]_{max} occurred at the target HC/NO_x ratio of 4 for the thiols. This

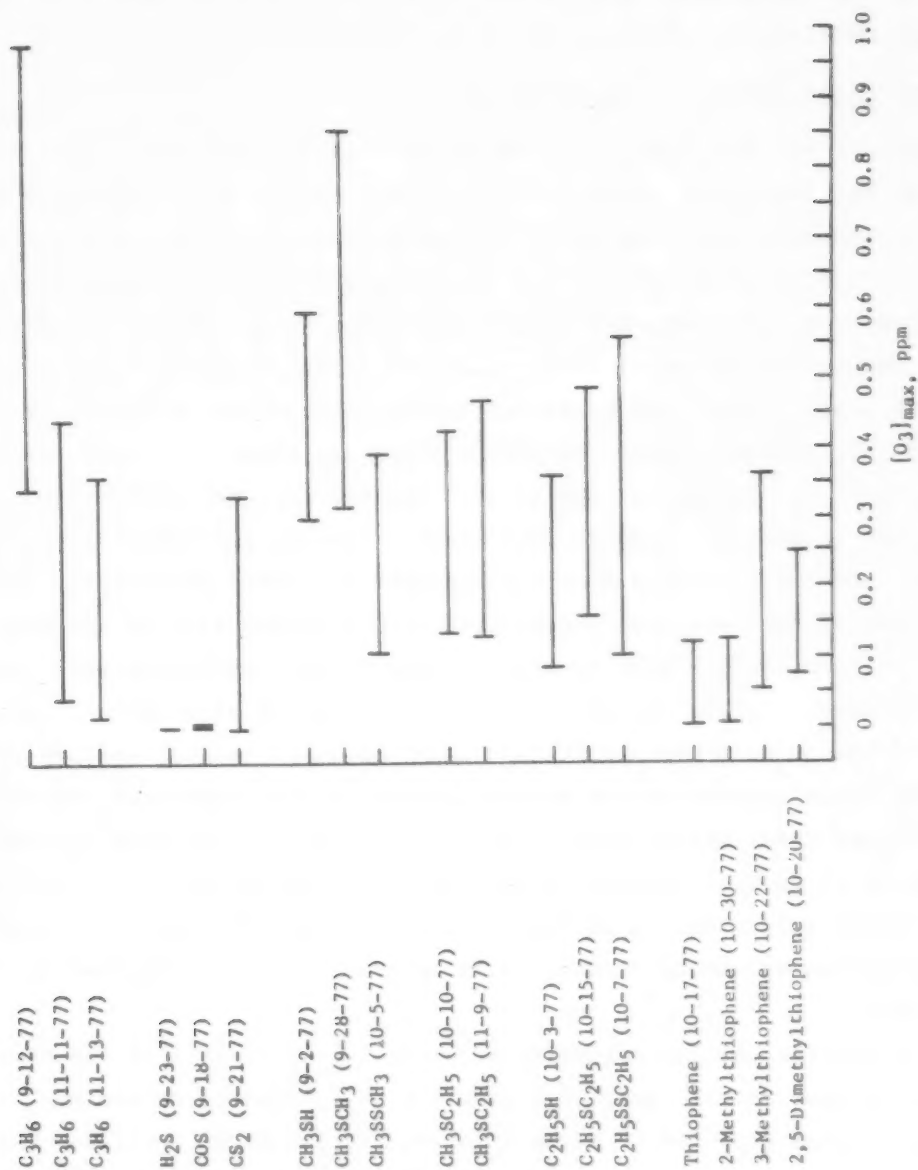


Figure 28. Range of maximum ozone concentrations produced by each tested compound.

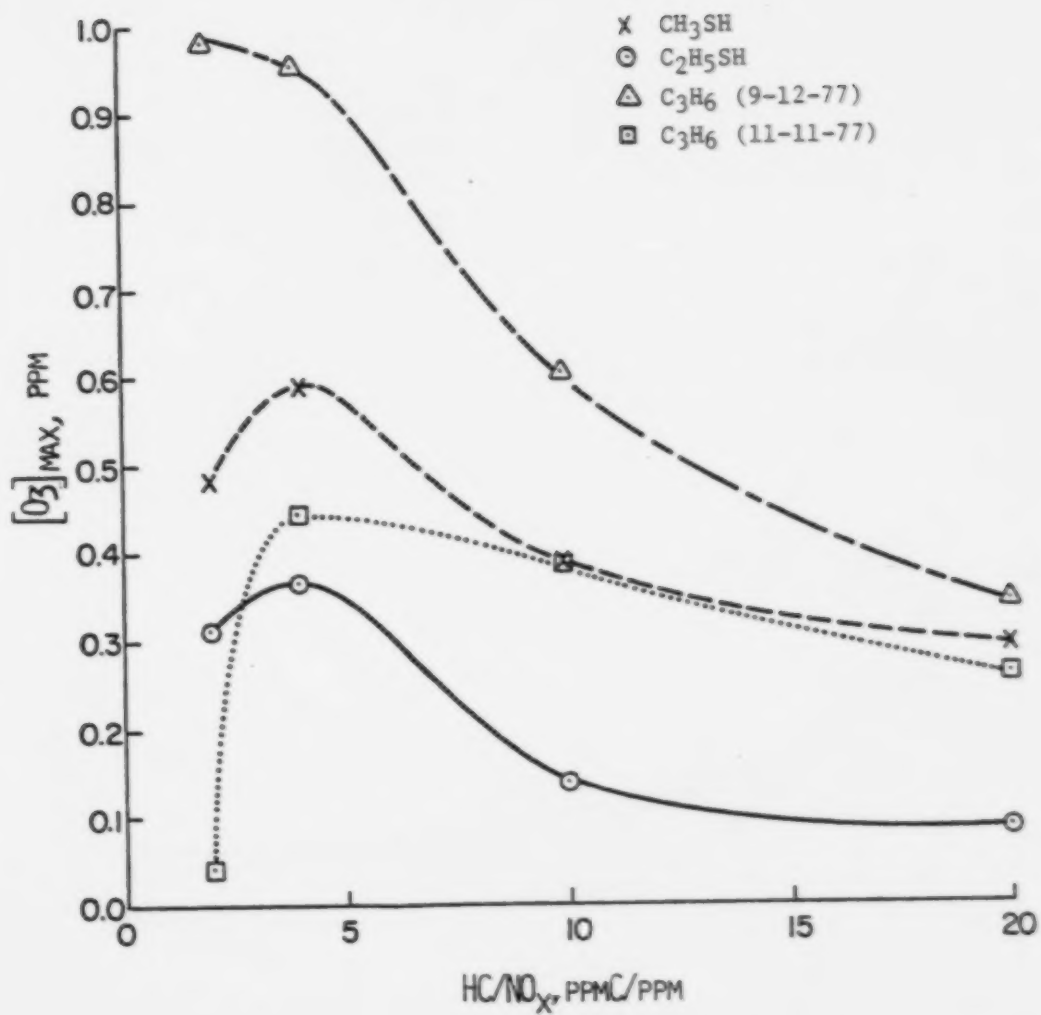


Figure 29. Maximum ozone concentrations produced at various target initial HC/NO_x ratios.

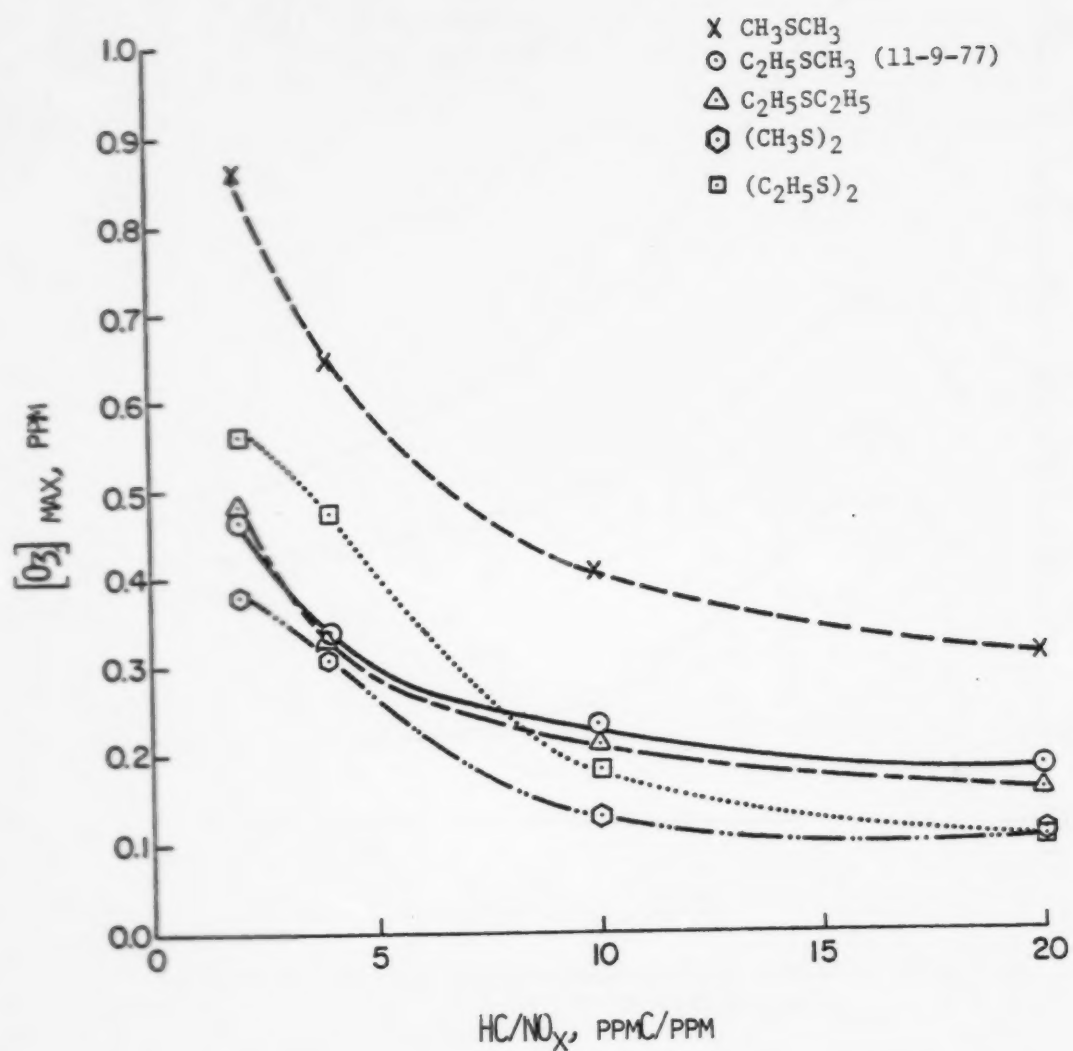


Figure 30. Maximum ozone concentrations produced at various target initial HC/NO_x ratios.

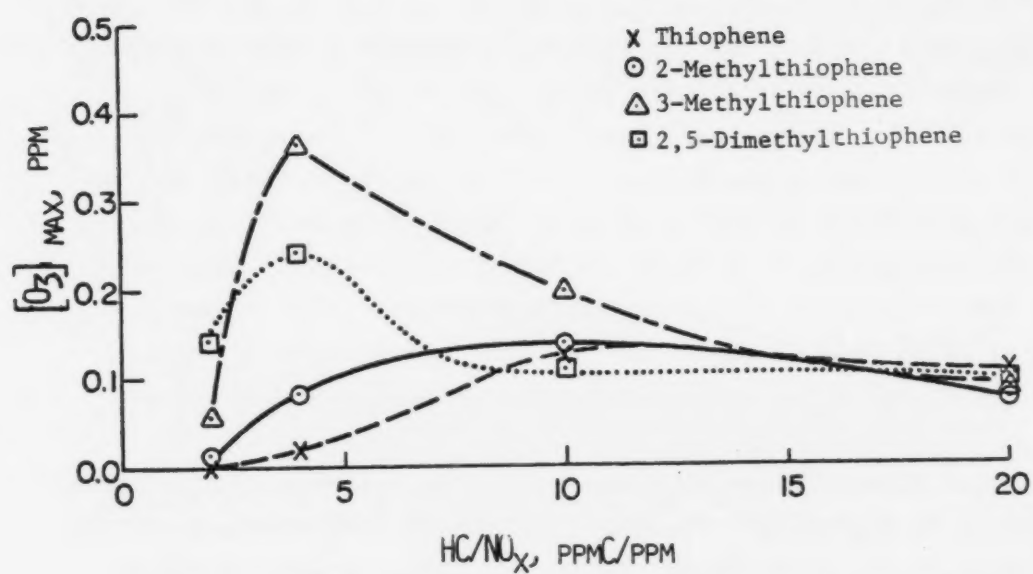


Figure 31. Maximum ozone concentrations produced at various target initial HC/NO_x ratios.

contrasts with the organic sulfides and organic disulfides that exhibited monotonic decreases in $[O_3]_{\max}$ as the target HC/NO_x ratio was increased from 2 to 20. At each HC/NO_x ratio, methanethiol produced more ozone on 2 September than did ethanethiol on 3 October. The impact of seasonal differences in the ambient temperature and sunlight profiles that occurred during the 1-month period that separated these experiments obscures the generality of this finding. Same-day experiments conducted at higher but equivalent target thiol concentrations (5 ppmC) on 26 August also suggest that methanethiol has a larger first-day ozone-generative potential than ethanethiol. The shape of the ozone-surface curves for the thiols resembles those also shown in Figure 29 for propene.

The relationship between the initial HC/NO_x ratio and the resulting $[O_3]_{\max}$ is presented graphically in Figure 30 for the organic sulfides and organic disulfides. As with the thiols, these compounds exhibit distinctive shapes for their ozone surfaces. For the organic sulfides, the $[O_3]_{\max}$ decreases sharply with increasing initial HC/NO_x ratio. The curves for methyl ethyl sulfide and ethyl sulfide are nearly coincident. Although the $[O_3]_{\max}$ curve for methyl sulfide is nearly parallel to those for the other sulfides, the photooxidation of methyl sulfide produces significantly more ozone than any of the other tested organosulfur species. The increased efficiency of ozone production for this compound in comparison to other tested species of similar structure must await mechanistic and modeling analyses.

As shown in Figure 31, the thiophenes exhibited maximum ozone production at intermediate HC/NO_x ratios. Thiophene and 2-methylthiophene produced the largest $[O_3]_{\max}$ at the target HC/NO_x ratio of 10, while 3-methylthiophene and 2,5-dimethylthiophene produced the largest $[O_3]_{\max}$ values at the target HC/NO_x ratio of 4. Among the thiophenes, 3-methylthiophene produced the most ozone. The addition of a methyl group onto the heterocyclic thiophene molecule modifies its reactivity as indicated by maximum ozone production. In addition, these results suggest that reactivity is significantly enhanced by the addition of a methyl group at the 3-position in comparison to adding either one or two methyl groups at the 2-position.

A distinct seasonal effect is apparent from the replicate propene runs (see Figure 29). The reduced temperature, sunlight intensity, and duration

of sunshine between September 12 and November 11 reduced the $[O_3]_{max}$ at each HC/NO_x ratio. In addition, the effect was most pronounced at the lowest HC/NO_x ratio. The duration of sunshine on each day was 718 and 624 minutes or 95 and 100 percent of the total possible. Maximum temperatures were 25.6 and 13.3° C. Based on computer simulations of photochemical HC/NO_x systems conducted by RTI, $[O_3]_{max}$ has been found to be sensitive to both the temperature and sunlight profiles. The relative importance of each seasonal influence in this case has not been examined.

Ozone generation at the lowest HC/NO_x ratio for propene was the most sensitive to seasonal influences. For these conditions, NO was in excess, and the system was both light- and hydrocarbon-limited. For a fixed initial hydrocarbon concentration, more time is required to oxidize the increased amounts of NO to NO₂ at low initial HC/NO_x ratios than at higher ratios. As a result, ozone production is delayed, and, if the duration of irradiation is limited, as it is in the diurnal cycle, then maximum ozone concentrations are reduced as well. The intensity and duration of sunlight in November was insufficient to generate significant ozone on the first day at the lowest HC/NO_x ratio. If the day could have been lengthened, it is likely that the $[O_3]_{max}$ would have been considerably higher. On the second day of the November experiments, the highest second-day $[O_3]_{max}$ were generated at the lowest initial HC/NO_x ratio. This also suggests that the low HC/NO_x ratio system was light-limited.

Fate of Nitrogen Oxides

On the average, at the maximum NO₂ concentration, NO₂ accounted for 47 percent of the initial NO_x in the experiments conducted with the thiophenes. In the experiments conducted with the thiols, organic sulfides, and organic disulfides, this value was 60 percent. The corresponding value in the propene-NO_x experiments was 73 percent. These results suggest that different chemical species and reactions determine the fate of NO_x in these three different chemical systems.

PAN data as determined by GC-EC were available for many of the experiments conducted in the current study. In several cases, two additional EC-responsive compounds were detected. These compounds have been tentatively identified as methyl and ethyl nitrate (MN and EN). The absolute concentra-

tions of these species are questionable, and this uncertainty does not permit a relative comparison of PAN, MN, and EN concentrations across the tested compounds.

Methyl nitrate was detected as a reaction product for propene and for the tested thiols, organic sulfides, and organic disulfides. Among the experiments conducted with the thiophenes, MN was found in appreciable amounts only for 2,5-dimethylthiophene. These findings are reasonable in view of the chemical structure of the organics involved.

Ethyl nitrate was detected as a reaction product only in experiments that involved C_3H_6 , $CH_3SC_2H_5$, C_2H_5SH , $C_2H_5SC_2H_5$, and $(C_2H_5S)_2$. Appreciable amounts of EN were not found in the experiments conducted with the thiophenes. These findings are also reasonable in view of the chemical structure of the organics involved.

In every case where EN was found, PAN was also found. In addition, PAN was detected in appreciable amounts as a reaction product for the three substituted thiophenes. Based on the chemical structure of H_2S , COS , CS_2 , CH_3SH , CH_3SCH_3 , and $(CH_3S)_2$, PAN is not expected as a reaction product of these compounds. Available data permit the verification of this hypothesis only for methylthiol and methyl disulfide.

The formation of PAN, MN, and EN as reaction products of the thiols, organic sulfides, and organic disulfides can be rationalized if the photo-oxidation of these species involves cleavage of S-C bond, which in the presence of air and NO_x leads to their formation. The formation of PAN and MN, but not EN, by the thiophenes provides clues that may elucidate the chemistry of the thiophene- NO_x systems.

Inspection of the first-day NO_x data in the appendix revealed unusual behavior in the experiments conducted with C_3H_6 , $CH_3SC_2H_5$, C_2H_5SH , $C_2H_5SC_2H_5$, $(C_2H_5S)_2$, and 3-methylthiophene. At the highest initial HC/NO_x ratios, the NO_x concentrations exhibited a loss of 5 to 20 ppb and a subsequent recovery. Examples of this behavior for experiments conducted with C_3H_6 and NO_x and with $(C_2H_5S)_2$ and NO_x are presented in Figures 32 and 33. Since the behavior was observed in experiments conducted both with propene and with organo sulfur compounds, the responsible product species does not necessarily contain sulfur. In addition, this behavior was generally associated with those reactants that contained an ethyl group in their structure, and the

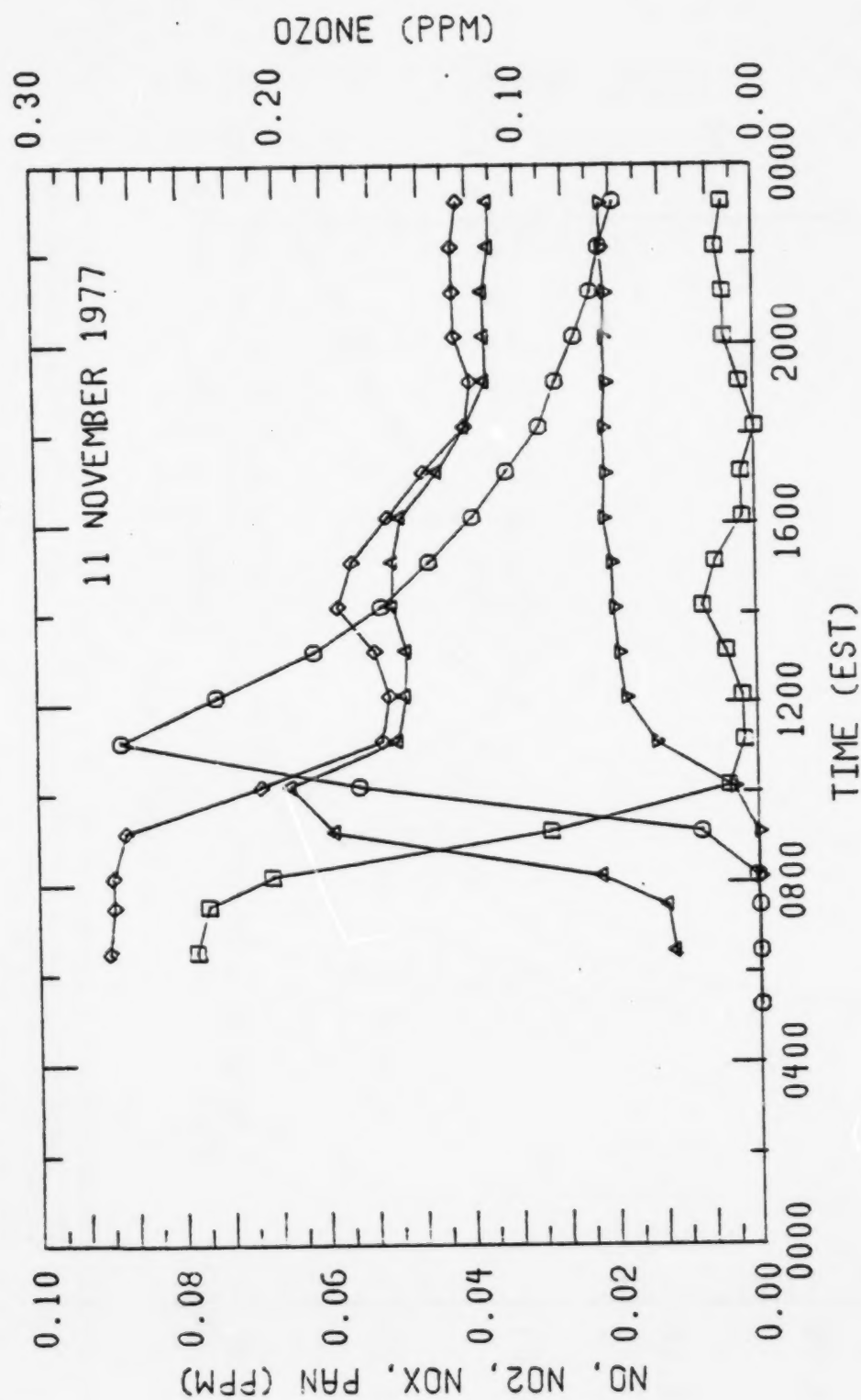


Figure 32. Concentration-time profiles of selected reactants and products for the 11 November 1977 C₃H₆-NO_x experiment conducted in RTI Chamber No. 1. Target initial conditions: 2.0 ppmC C₃H₆ and 0.1 ppm NO_x. Symbol key: (o) O₃; (□) NO; (Δ) NO₂; (◇) NO_x; and (▽) PAN.

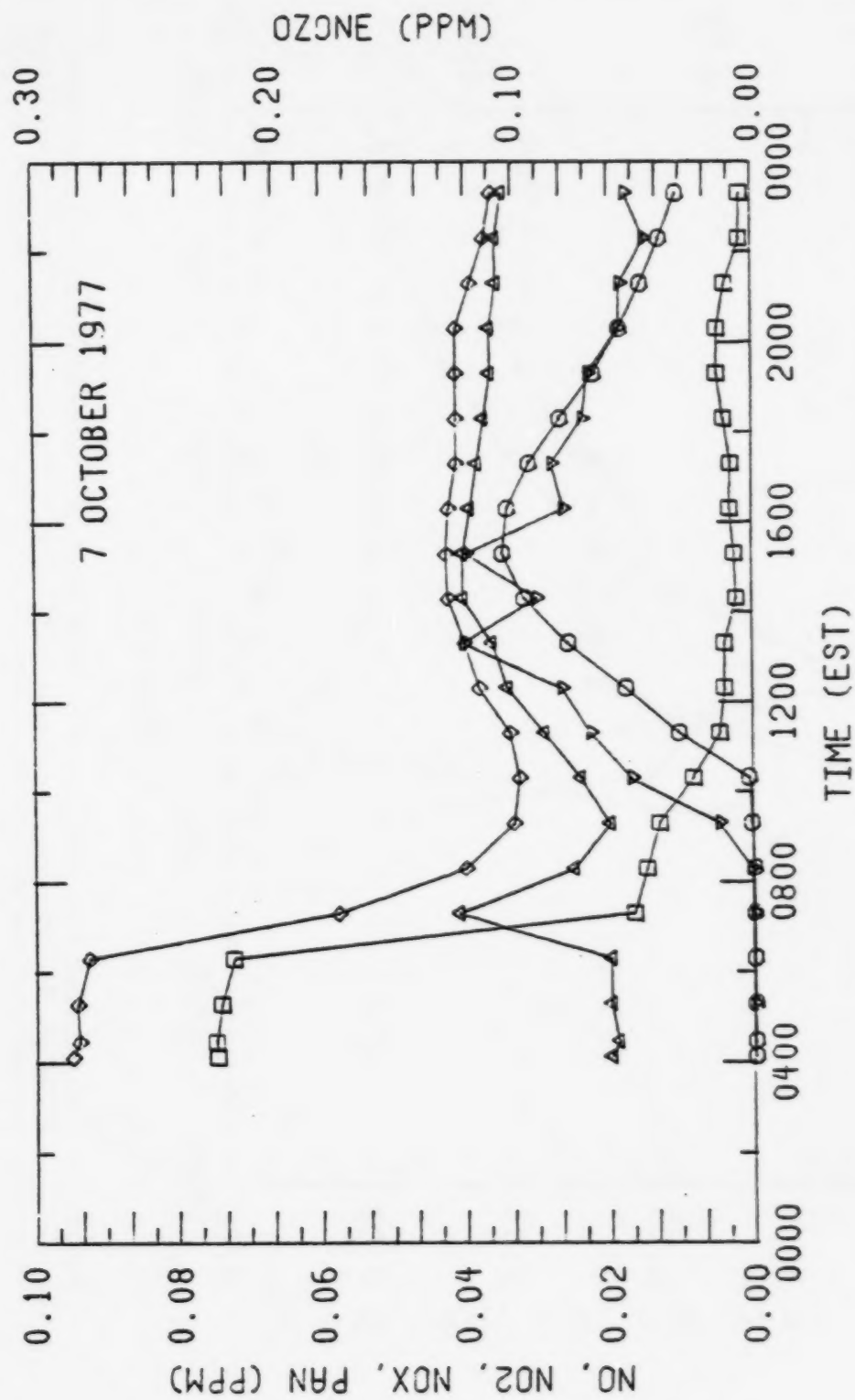


Figure 33. Concentration-time profiles of selected reactants and products for the 7 October 1977 (C₂H₅S)₂-NO_x experiment conducted in RTI Chamber No. 2. Target initial conditions: 2.0 ppmC (C₂H₅S)₂ and 0.1 ppm NO_x. Symbol key: (o) O₃; (□) NO; (Δ) NO₂; (○) NO_x; and (▽) PAN.

timing of this phenomenon coincided with the initial accumulation of PAN. This behavior was not observed at the low initial HC/NO_x ratios, although it may have been obscured by the higher NO_x concentrations employed in these experiments. It is likely that a transient nitrogen-containing species was responsible for this behavior. This species was either not delivered to the NO_x analyzer as a result of interactions with chamber walls or the sampling system or it could not be detected by the chemiluminescent NO_x analyzer that was employed. Although the identity of this hypothetical species is unknown, such species as pernitric acid and its organic analogues may have been involved.

A nitrogen mass balance was estimated for each experiment based on chemiluminescent NO_x concentrations determined initially and again during the 1700 EST hour of the first day. For each tested compound, the range of these nitrogen balances is presented in Figure 34. The best nitrogen balances occurred in the experiments conducted with H₂S. Since the fraction of accountable NO_x exceeded unity in this case, interferences by H₂S or reaction products may have been responsible. The nitrogen balances also approached unity in the experiments conducted with COS. In this case the nitrogen balances were not sensitive to initial conditions, as indicated by the small range. The poorest nitrogen balances occurred for the experiments conducted with methanethiol, methyl sulfide, and methyl disulfide. Generally less than 15 percent of the initially present NO_x could be accounted for in these cases. In addition to being nearly identical, these nitrogen balances were insensitive to initial conditions. For the experiments conducted with methyl ethyl sulfide, ethane thiol, ethyl sulfide, and ethyl disulfide, the nitrogen balances again were relatively insensitive to initial conditions and were similar, with approximately 20 to 45 percent of the initially present NO_x accountable at the 1700 EST hour of the first day. For the thiophenes, the nitrogen balances differed widely depending on the molecular structure. These balances became decreasingly sensitive to initial conditions with the substitution of methyl groups on to the thiophene molecule. The range of nitrogen balances for carbon disulfide was similar to those for propene. In these cases, the nitrogen balances were very sensitive to initial conditions and ranged from 25 to 75 percent. It is interesting to note that no seasonal influences on the ranges of nitrogen balances were exhibited in either the C₃H₆-NO_x experiments or the CH₃SC₂H₅-NO_x experiments.

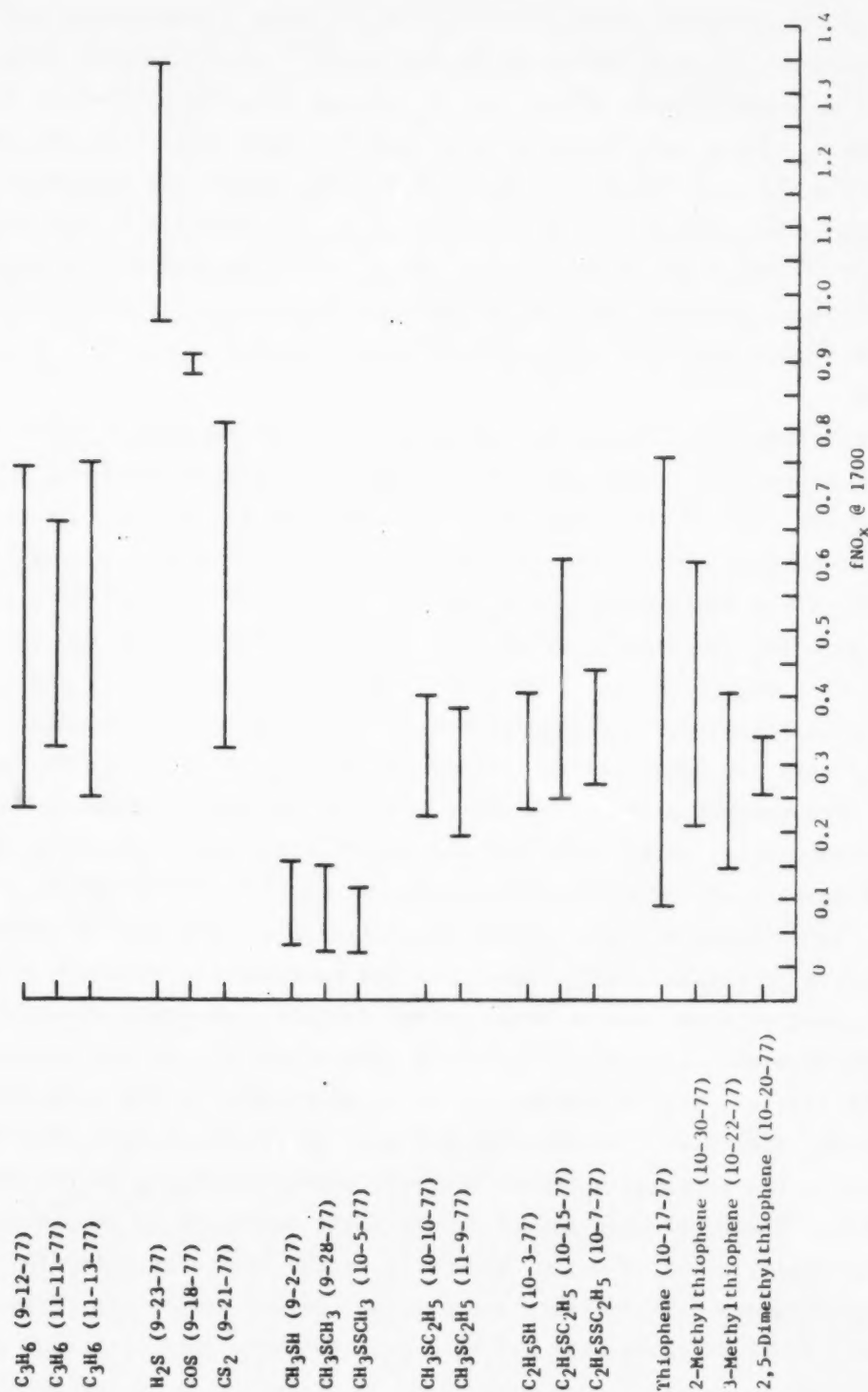


Figure 34. Range of fractions of initially present NO_x that could be accounted for at the 1700 EST hour of the first day.

The unaccountable product nitrogen may be nitric acid, or other undetermined nitrogen-containing species. These nitrogen species were presumably deposited on the chamber walls. The extent to which this deposition is reversible is currently undefined. Interaction of these species between the chamber walls and the gas phase may contribute to unusual second-day NO_x behavior. In the experiments conducted at the target HC/NO_x ratio of 20, the lowest initial NO_x concentration, the second-day NO_2 concentration increased by 10 ± 5 ppb. This increase occurred between the 0500 and 1200 EST hours (± 2.5 hours). The magnitude of the second-day increases in NO_2 concentration was examined for associations with duration of sunshine and with daily maximum temperatures for 23 cases. No associations were found. Although second-day increases of NO_x concentrations have been noted for other chemical systems, they are unexpected and cannot be explained at this time. The fate of NO_x in photochemically reacting systems is largely unknown.

Disappearance Rate of the Test Species

Estimates were made of the times at which approximately one-half of the originally present test compound had been consumed. Each estimate was based on a measured or assumed initial concentration and the time, interpolated from the data in the appendix, where the concentration had fallen to one-half of its original value. For each test compound the range of hours of irradiation past sunrise required to consume one-half of the initially present compound is presented in Figure 35.

If the time to one-half consumption is a rough indicator of disappearance rate, then Figure 35 suggests that many of the tested compounds were consumed rapidly during these experiments. The available data did not permit precise estimates for H_2S , COS , and CS_2 ; however, they do suggest that more than one day of irradiation was required to achieve one-half consumption of each of these compounds. In addition, it is likely that COS was the least reactive and most stable test species under the experimental conditions employed in the current study. The thiols and organic sulfides had similar ranges of disappearance rates. Among all the tested compounds, the organic disulfides displayed the fastest disappearance rates. As noted earlier, the fastest conversion of NO to NO_2 also occurred in the experiments

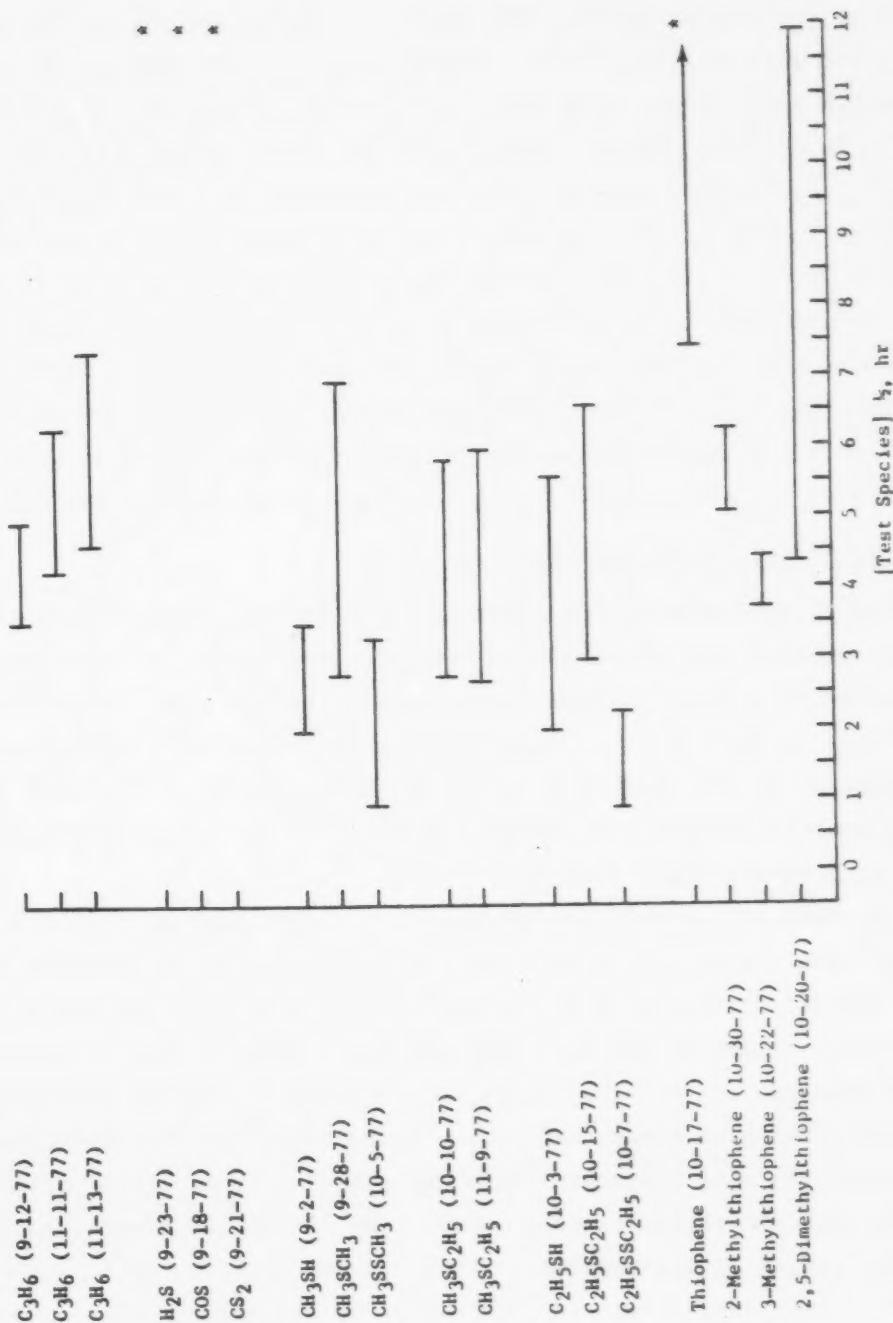


Figure 35. Range of the hours of irradiation past sunrise required on the first day to consume one-half of the initially present test compound; * indicates that for the experimental conditions employed more than one day of irradiation was required to achieve one-half consumption.

conducted with these two compounds. Among the thiophenes, 3-methylthiophene displayed the fastest disappearance rates. For 3-methylthiophene and 2-methylthiophene, the disappearance rates were insensitive to initial conditions. This contrasts with the behavior of thiophene and 2,5-dimethylthiophene, which displayed large ranges of disappearance rates. Thiophene itself displayed the slowest disappearance rates among the tested thiophenes. A seasonal influence was exhibited in the $C_3H_6-NO_x$ experiments: the propene disappearance rates were slightly slower and more sensitive to initial conditions in November than in September. However, no significant seasonal influence on methyl ethyl sulfide disappearance rates was apparent for the replicate $CH_3SC_2H_5-NO_x$ experiments conducted 1 month apart.

Gaseous Reaction Products: SO_2 and COS

Sulfur dioxide was found as a reaction product in at least one of the experiments conducted with mixtures of NO_x and each tested sulfur-containing compound except COS, where SO_2 data were not available. Since the target initial concentrations of the sulfur compounds were equivalent on a carbon basis but not on a sulfur basis, the measured maximum SO_2 concentrations were normalized to the equivalent of an initial concentration of 1 ppmS. The initial concentrations used were identical to the measured and assumed concentrations used earlier in the determination of the times to one-half consumption of the test compound. For each test compound, the range of normalized maximum SO_2 concentrations found on the first day of the experiment is presented in Figure 36.

The largest normalized maximum SO_2 concentrations were produced by the CH_3SH-NO_x system. Methanethiol, methyl disulfide, ethyl disulfide, 3-methylthiophene, and 2,5-dimethylthiophene exhibited large SO_2 production potentials. Maximum normalized SO_2 concentrations in excess of 0.25 ppm were produced in the experiments conducted with these compounds. Methyl disulfide and ethyl disulfide produced similar ranges of $[\overline{SO_2}]_{max}$. In addition, they were previously indicated to have been highly reactive by their short times both to one-half consumption and to $NO-NO_2$ crossover. Methyl sulfide, methyl ethyl sulfide, and ethyl sulfide produced low but similar normalized concentrations of SO_2 . Based on these apparent associations between molecular structure and SO_2 production, the large difference in SO_2 production by

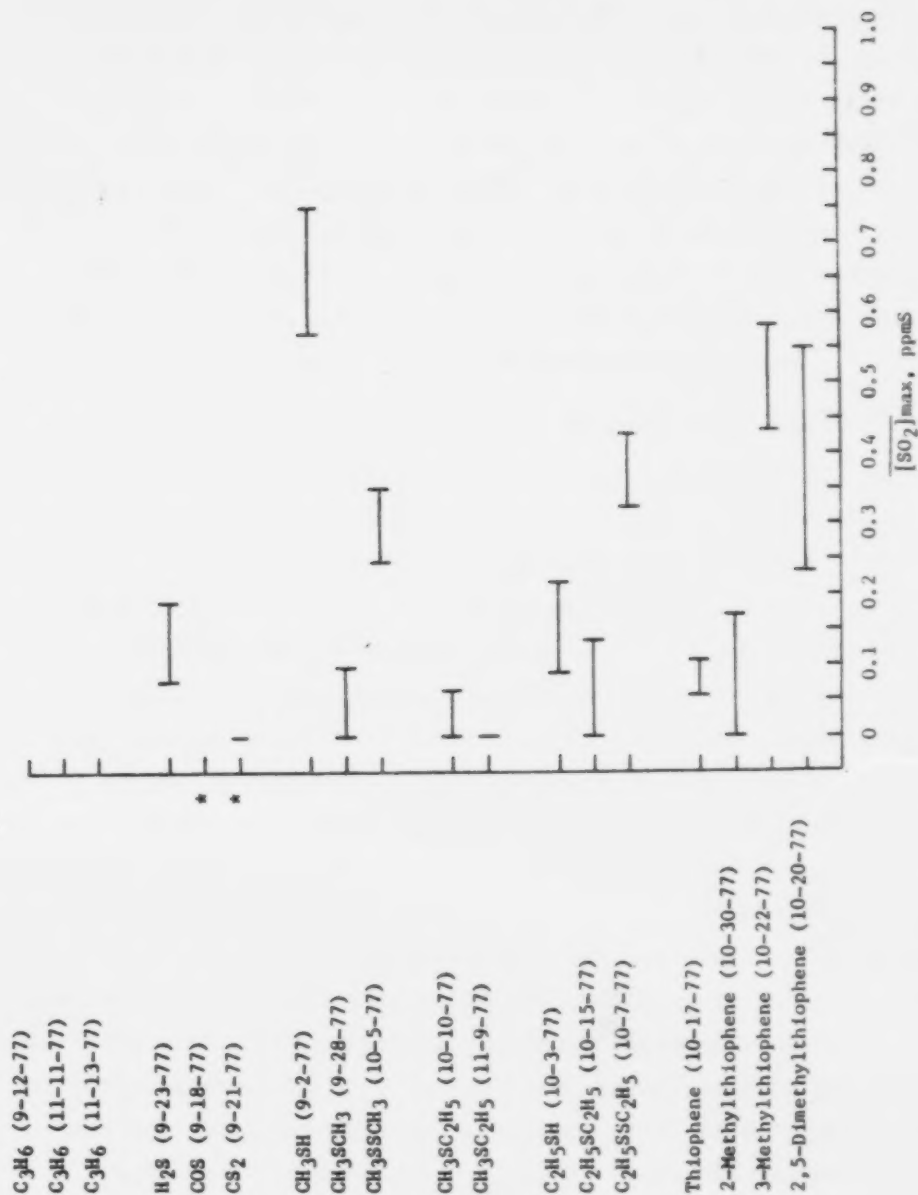


Figure 36. Range of maximum sulfur dioxide concentrations normalized to the equivalent of an initial concentration of 1 ppmS for each test compound; * indicates missing data.

methanethiol and ethanethiol was unexpected. Among the thiophenes, 2,5-dimethylthiophene and 3-methylthiophene produced significantly more SO_2 than thiophene or 2-methylthiophene. In addition, based on the ranges of $[\overline{\text{SO}_2}]_{\text{max}}$ values, SO_2 production by 2,5-dimethylthiophene was highly sensitive to initial conditions. The normalized SO_2 maxima generated by the $\text{CH}_3\text{SC}_2\text{H}_5\text{-NO}_x$ system on 10 October exceeded the trace quantities detected on 9 November. These differences suggest but are not sufficiently large to be conclusively indicative of seasonal effects.

In addition to sulfur dioxide, carbonyl sulfide was observed in many cases as a reaction product. It was observed as the major product in the experiments conducted with the $\text{CS}_2\text{-NO}_x$ system, where first-day maximum concentrations ranged from 0.24 to 0.76 ppmS. Small peaks were detected by the sulfur analyzer in the experiments conducted with methyl sulfide, methyl ethyl sulfide, methyl disulfide, ethanethiol, ethyl disulfide, and each of the thiophenes. These peaks had retention times similar to that for COS and thus have been tentatively identified as COS. Although the peak heights were observed to increase during the day, they were not sufficiently large to permit quantification. These findings indicate that COS was a minor reaction product for at least nine of the tested sulfur-containing compounds.

Particulate Sulfur and Its Distribution as a Reaction Product

Particulate sulfur was found as a reaction product in at least one of the experiments conducted with mixtures of NO_x and each of the tested sulfur-containing compounds. Since the target initial concentrations of the sulfur compounds were equivalent on a carbon basis but not on a sulfur basis, the measured maximum TPS concentrations were normalized to the equivalent of an initial concentration of 1 ppmS. The initial concentrations used were identical to the measured and assumed concentrations used earlier in the normalization of maximum SO_2 concentrations. For each test compound, the range of normalized maximum TPS concentrations found on the first day of the experiment is presented in Figure 37.

The largest normalized particulate sulfur concentrations were produced by the $\text{CH}_3\text{SH-NO}_x$ system. Both methanethiol and methyl disulfide exhibited relatively large particulate sulfur production potentials. Maximum normalized TPS concentrations exceeded 0.15 ppmS in at least one of the experiments

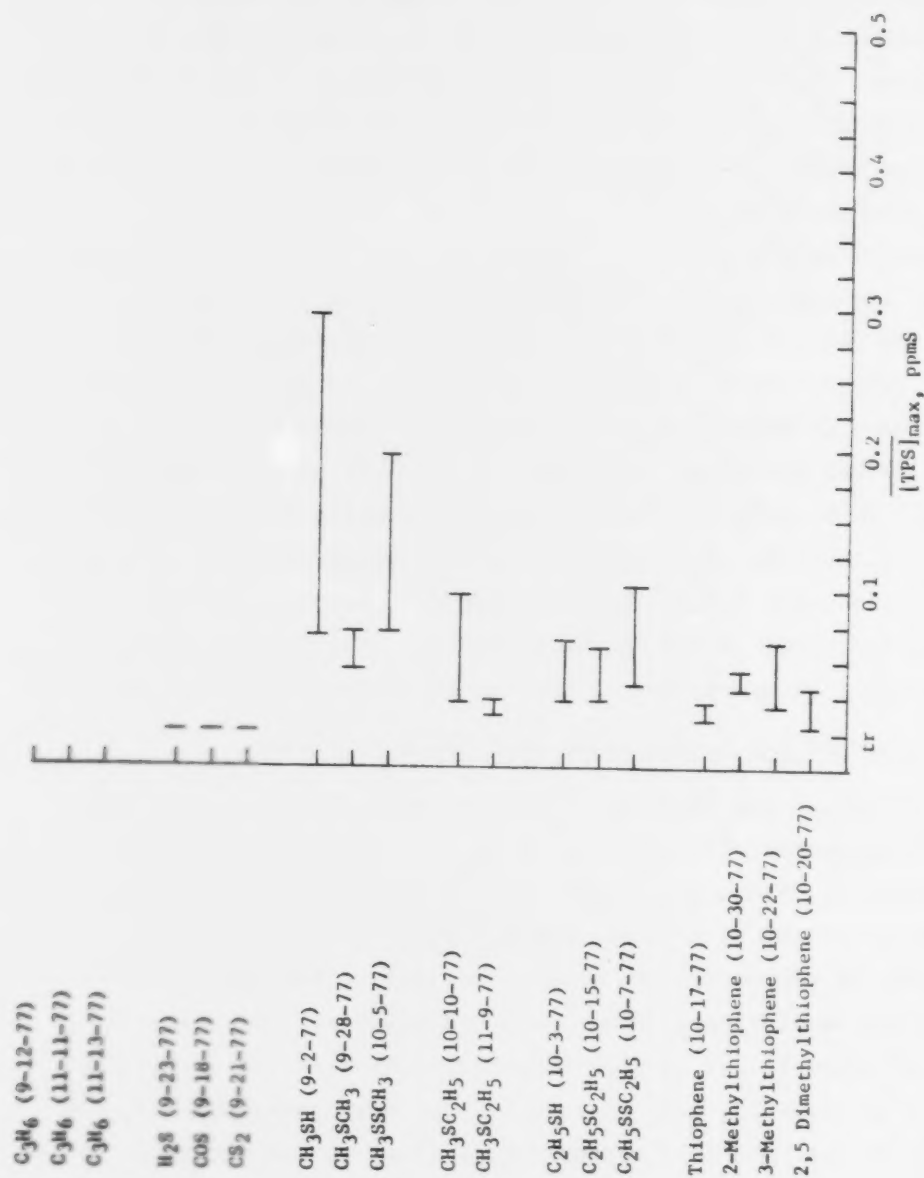


Figure 37. Range of maximum total particulate sulfur concentrations normalized to the equivalent of an initial concentration of 1 ppmS for each test compound.

conducted with these compounds. In addition, based on the ranges of maximum [TPS] values, particulate sulfur production by methanethiol and methyl disulfide was highly sensitive to initial conditions. Methyl sulfide, methyl ethyl sulfide, ethanethiol, ethyl sulfide, ethyl disulfide, and 3-methylthiophene exhibited moderate particulate sulfur production potentials. Maximum [TPS] fell between 0.05 and 0.10 ppmS for at least one of the experiments conducted with each of these compounds. The three remaining thiophenes generated small [TPS] maxima, which ranged between trace amounts and 0.05 ppmS. The smallest amounts of particulate sulfur were produced by hydrogen sulfide, carbonyl sulfide, and carbon disulfide. Only trace amounts of particulate sulfur were detected in the experiments conducted with these compounds.

Seasonal influences were manifest in the [TPS] maxima of the two sets of $\text{CH}_3\text{SC}_2\text{H}_5\text{-NO}_x$ experiments conducted approximately 1 month apart. Significantly higher maximum [TPS] values were found on 10 October than on 9 November. This is somewhat unexpected, since significant seasonal differences were not apparent in times to NO-NO_2 crossover, nitrogen balances at 1700 EST, disappearance rates of the test species, and maximum ozone concentrations. This suggests that the photochemical generation of particulate sulfur by compounds such as those tested in the current study is more sensitive to seasonal environmental factors such as solar radiation than are the gas-phase processes that lead to ozone production.

The times of occurrence of maximum sulfur dioxide and particulate sulfur concentrations were examined. Since SO_2 concentrations were monitored once an hour, whereas, TPS data were collected once every 2 or 3 hours, the time scales were not entirely compatible for such comparisons. Despite this shortcoming, maximum TPS concentrations preceded maximum SO_2 concentrations in many cases. In the experiments conducted with H_2S , COS , and CS_2 , either missing or low concentration data prevented meaningful comparisons. In at least one of the experiments conducted with each of the remaining test species, however, maximum TPS concentrations either preceded or were coincident with maximum SO_2 concentrations. This finding suggests points for additional investigation.

- The particulate sulfur may be hypothesized to exist as sulfate. Alternatively, since its identity is unknown, it is conceivable that the particulate sulfur could exist as an organic-sulfur complex. Efforts should be directed at speciation of particulate sulfur.

- The oxidation of most of the tested sulfur species may be hypothesized to first yield SO_2 with subsequent generation of particulate sulfur, presumably as sulfate. The near coincident timing of $[\text{TPS}]_{\text{max}}$ and $[\text{SO}_2]_{\text{max}}$ maxima does not support this hypothesis. Alternate pathways of particulate sulfur formation that do not require SO_2 as an intermediate should be examined.
- Irradiated mixtures of SO_2 , hydrocarbons, and nitrogen oxides are known to yield particulate sulfur as an oxidation product. The chemical behavior of such systems should be compared to that of systems which include one or more of the test species from the current study, in addition to hydrocarbons and nitrogen oxides. Findings from such an investigation may elucidate further the particulate sulfur formation mechanism.

The ratio of product sulfur as particulate to the total accountable reacted sulfur ($[\text{TPS}]$ plus $[\text{SO}_2]$) was determined for many of the tested compounds. This ratio, R , was calculated based on data collected during or interpolated for the hour of occurrence of the maximum SO_2 concentration. It permits an assessment of the distribution of accountable product sulfur between the gas and particulate phases. For each compound, where available data permit, the range of first-day R values is presented in Figure 38.

Generally, these data indicate that the majority of the accountable product sulfur for the tested species existed as SO_2 and that less than 20 percent of accountable product sulfur existed in the particulate phase. Ratios in excess of 0.2 occurred for methanethiol, methyl sulfide, methyl disulfide, and methyl ethyl sulfide. The relatively high R values for methanethiol and methyl disulfide are associated with the large particulate sulfur production potential exhibited by these compounds and noted previously (see Figure 37). Based on the large range of R values of the experiments conducted with methanethiol, the distribution of product sulfur between the gas and particulate phases was highly sensitive to initial conditions for this species. Data were available to permit the determination of R values in only two of the four experiments conducted with methyl sulfide and in two of the eight experiments conducted with methyl ethyl sulfide. These cases, however, represent the highest R values found among all the compounds tested. Although the high R values appear to be associated with the presence of the methyl-sulfur grouping in the test species, the factors responsible for this behavior remain to be defined.

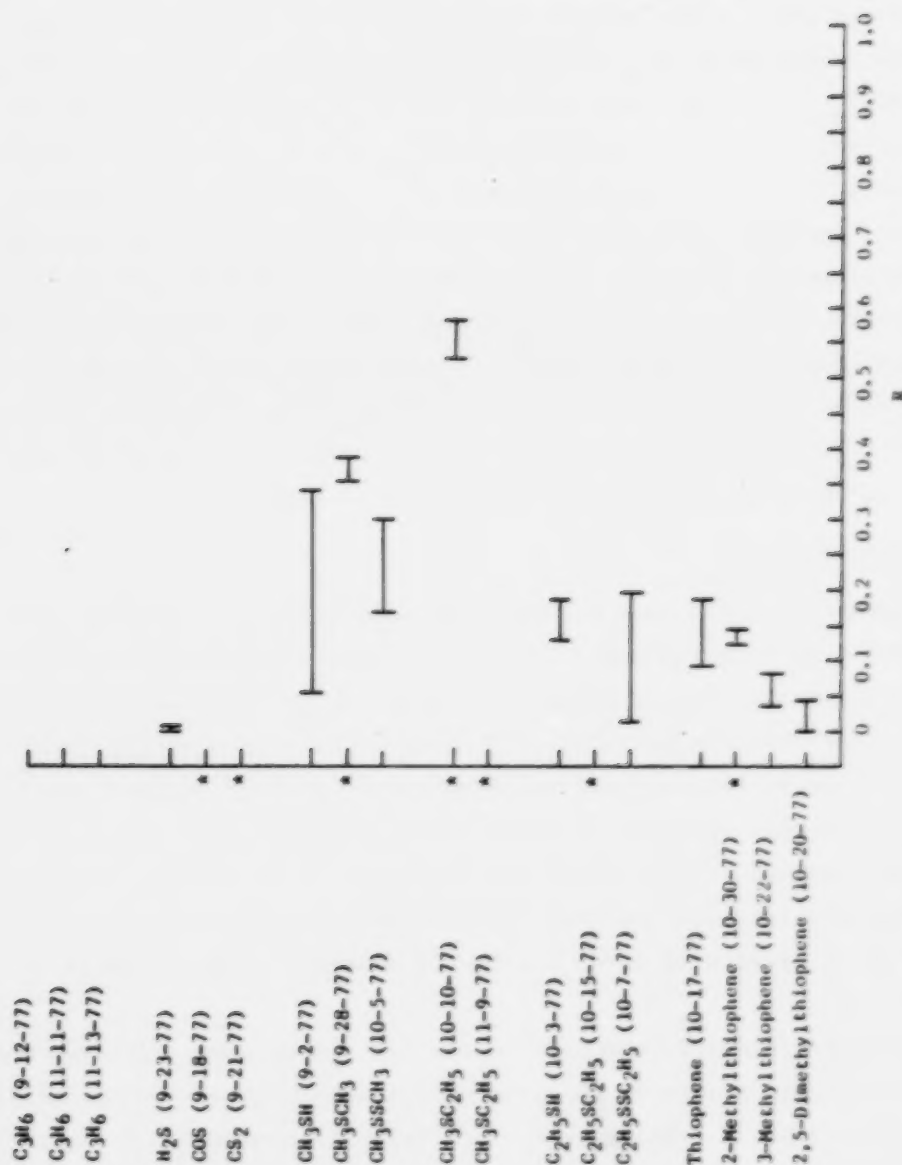


Figure 38. Range of R values (ratio of product sulfur as particulate to the total accountable reacted sulfur) for each test species; * indicates that missing data prevented the determination of R in one or more cases.

Losses of particulate sulfur to the chamber walls affect the particulate sulfur concentration and parameters that are based on the particulate sulfur concentrations. The measured $[\text{TPS}]_{\text{max}}$ values are the net result of production and removal processes. Presumably, the production processes are photochemical, whereas the major removal process is deposition on the chamber walls. Wall losses of particulate sulfur are significant in the current study. Particulate sulfur decay constants were determined for those cases where two or more $[\text{TPS}]_{\text{max}}$ data were available on the first day during the period between the time of occurrence of the maximum $[\text{TPS}]_{\text{max}}$ and of sunset. TPS half-lives ranged from 1.7 to 7.3 hours with a mean of 3.4 hours. Such variables as temperature, sunlight, humidity, and particle size distribution are expected to influence the TPS half-lives. The role of these factors and their impact on particulate losses remain to be defined. Thus, the seasonal differences noted above in the experiments conducted with methyl ethyl sulfide as well as the relative ranking of the ranges of $[\text{TPS}]_{\text{max}}$ shown in Figure 37 were influenced to an unknown extent by particulate sulfur losses to the chamber walls. These results should be interpreted with some caution.

Nighttime Ozone Decay

The behavior of mixtures of ozone and purified air in the RTI smog chambers has been examined under irradiation and in the dark using initial ozone concentrations ranging between 0.4 and 1.0 ppm. The results indicate that dark phase ozone decay in the RTI chambers is approximately first order. First order behavior has not been established at initial concentrations below 0.4 ppm, although it seems reasonable to expect this behavior at lower concentrations. Ozone decay was discussed in an earlier section on chamber characterization, and test results summarized in Table 6 indicate that dark phase ozone half-lives in the RTI chambers ranged from 24 to 122 hours.

Previous experiments conducted in our laboratory have indicated that ozone is relatively stable in the presence of methanethiol, methyl sulfide, or methyl disulfide.⁴² Dark-phase ozone half-lives exceeded 50 hours in the presence of approximately 5 ppmV of each of these compounds. It may be reasonable to expect similar behavior for methyl ethyl sulfide, ethanethiol, ethyl sulfide, and ethyl disulfide. Although ozone has been shown to be

more reactive with thiophene than methanethiol, methyl sulfide, or methyl disulfide, the shortest dark-phase ozone half-life in the presence of thiophene (at 4.3 ppmV) was found to be 15 hours. Thus, mixtures of ozone and any of the tested thiophenes might be expected to exhibit shorter ozone half-lives than mixtures of ozone and the tested alkyl-sulfur species. In addition, carbon disulfide is known to react with ozone; however, it is difficult to extrapolate these findings to the experimental conditions employed in the current study.^{43 44}

In many of the two-day experiments performed in the current study, ozone was a reaction product. To infer the presence of ozone-reactive product species, dark-phase ozone half-lives were determined for the nighttime period between 2000 EST on the first day and 0400 EST on the second day. The ozone half-life for the experiment that produced the largest first-day $[O_3]_{\max}$ is represented in Figure 39 for each of the tested compounds.

The half-lives in Figure 39 fall into three general categories. The experiments conducted with propene exhibited the longest half-lives, ranging from 25 to 40 hours. These values are not significantly different from those measured in the presence of purified air. Half-lives ranging from 9 to 18 hours were observed in experiments conducted with carbon disulfide, methanethiol, methyl sulfide, methyl disulfide, methyl ethyl sulfide, ethanethiol, ethyl sulfide, and ethyl disulfide. Relatively short half-lives occurred in the experiments conducted with the thiophenes. These values ranged from 3.6 to 6.6 hours.

In many cases, by the 2000 EST hour on the first day of the experiment, the initial reactant had been essentially consumed. This was the case for the experiments conducted with propene, methanethiol, methyl sulfide, methyl disulfide, methyl ethyl sulfide, ethanethiol, ethyl sulfide, and ethyl disulfide. Thus, even if these species were reactive with ozone (as is propene, for example), they did not exist at sufficient concentration levels to act as ozone-destructive agents. Thus, these results suggest the possible presence of undefined ozone-reactive reaction products in the experiments conducted with methanethiol, methyl sulfide, methyl disulfide, methyl ethyl sulfide, ethanethiol, ethyl sulfide, and ethyl disulfide.

Although CS_2 concentration data were not available, if the target initial concentration was achieved and if its reaction produced COS with a

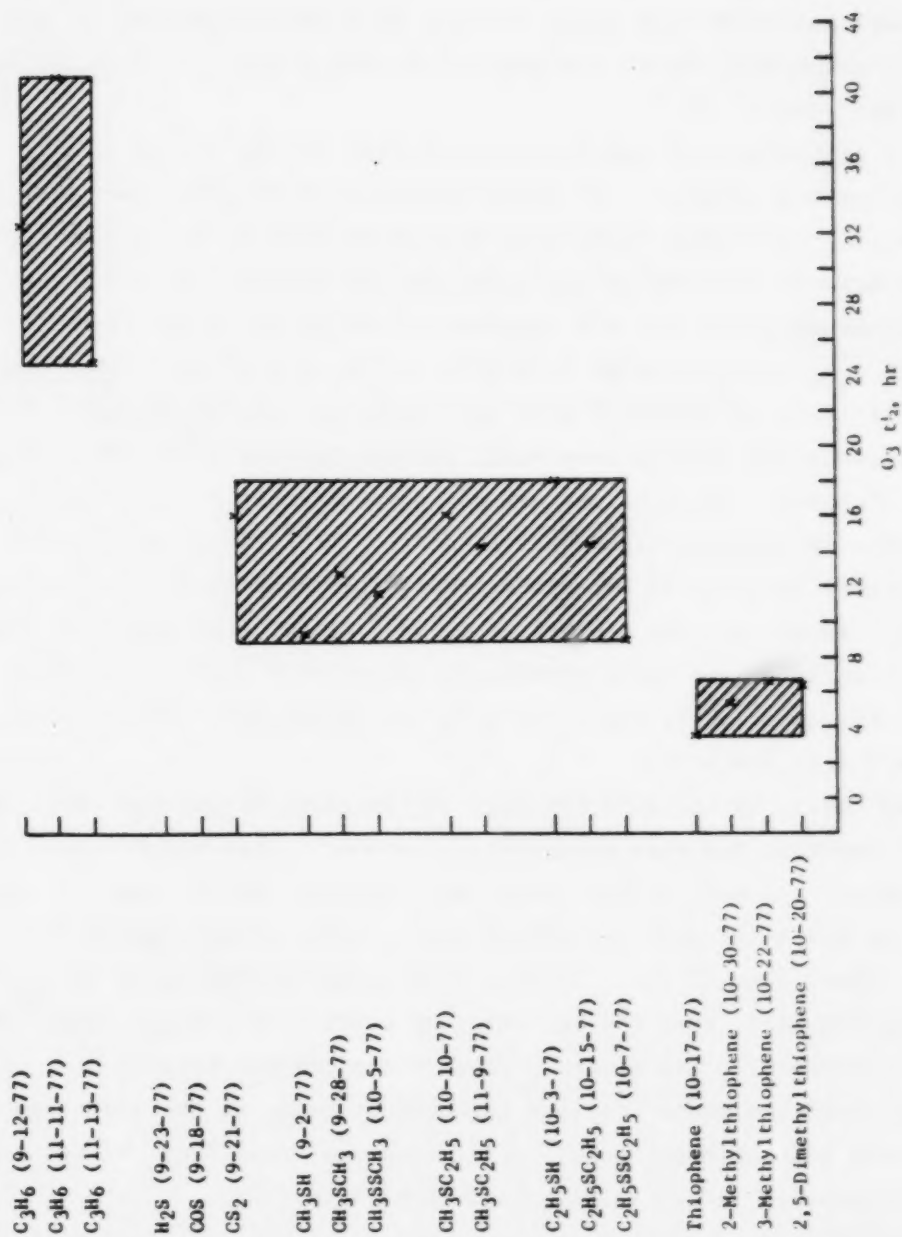


Figure 39. Ozone half-life for the experiment that produced the largest first-day maximum ozone concentration with each tested compound.

yield of unity, then at 2000 EST approximately 1.6 ppmV of CS₂ remained unreacted. Since ozone is known to react with CS₂, the moderate ozone half-life in the experiment conducted with CS₂ (17 hours) may have resulted from the reaction of ozone with previously unreacted CS₂. The lack of information on the rate of the O₃-CS₂ reaction for the experimental conditions employed prevents confirmation of this hypothesis; however, it does not prevent speculation on the presence of ozone-reactive products.

For the conditions under consideration in this analysis, significant amounts of the thiophenes remained unreacted at the 2000 EST hour. If the ozone-thiophene reaction rate discussed previously is representative of ozone destruction by reaction with each of the tested thiophenes, then the concentrations of these species were too low to account for the short ozone half-lives that were observed. The largest ozone maxima for three of the tested thiophenes were low. Among all the tested compounds only those experiments conducted with thiophene, 2-methylthiophene, and 2,5-dimethylthiophene failed to generate at least one [O₃]_{max} value in excess of 0.3 ppm. As the ozone concentration is reduced, it becomes a sensitive indicator of destructive agents. Since first-order ozone decay has not been verified to occur at concentrations below 0.4 ppm in the RTI chambers, wall effects or other factors may have influenced ozone behavior at low concentrations. The available data do not permit resolution of the importance of ozone destruction by residual reactants or of wall-related factors at low ozone concentrations on the short ozone half-lives observed during the thiophene experiments. The results do suggest the formation of undefined ozone-reactive reaction products in the experiments conducted with the thiophenes.

Net Ozone Generation on the Second Day

The accumulation of ozone in smog chambers is the net result of synthesis and destructive processes. Ozone is synthesized by photochemical processes. At night in the absence of sunlight, ozone-destructive processes prevail. During the night following the first day of an experiment, the ozone concentration declines as the ozone that was generated during the previous daylight period is destroyed by homogenous reactions with various reactants and products and by heterogeneous interactions with the chamber walls. On the morning of the second day, ozone synthesis begins with the

reintroduction of sunlight to the system. When the ozone synthesis rate begins to exceed the destruction rate, the concentration profile passes through a minimum and the ozone concentration increases. In the current investigation, the difference between this minimum and the maximum concentration that accumulates on the second day is known as the net ozone concentration. The second-day net ozone concentration presumably reflects the ozone production potential of a chemical system after one diurnal cycle. For many of the tested compounds, the ranges of second-day net ozone concentrations are presented in Figure 40. Data were not presented in cases where the second-day CU-SR was less than 200 cal cm^{-2} . In addition, those compounds were identified wherein the second-day net ozone concentration exceeded the first-day maximum ozone concentration in at least one of the four experiments.

The largest second-day net ozone concentration was produced in an experiment conducted with methanethiol. Net ozone concentrations exceeding 0.2 ppm accumulated in at least one experiment conducted with propene, with carbon disulfide, with methanethiol, with ethanethiol, and with 2,5-dimethylthiophene. Based on the relatively large ranges of net ozone concentrations for these species, second-day ozone production by these compounds was highly sensitive to the (first-day) initial conditions. In contrast, essentially no ozone accumulated on the second day of experiments conducted with H_2S and with COS.

A seasonal effect on net ozone production was apparent in the results of the propene- NO_x experiments. Net ozone production was significantly higher in the September experiments than in the November experiments. In addition, the second-day net ozone concentration exceeded the first-day maximum in at least one experiment conducted with propene, with carbonylsulfide, with carbon disulfide, with each thiol, and with each thiophene. These findings are discussed in more detail in the earlier sections that address the chemical behavior of each tested compound.

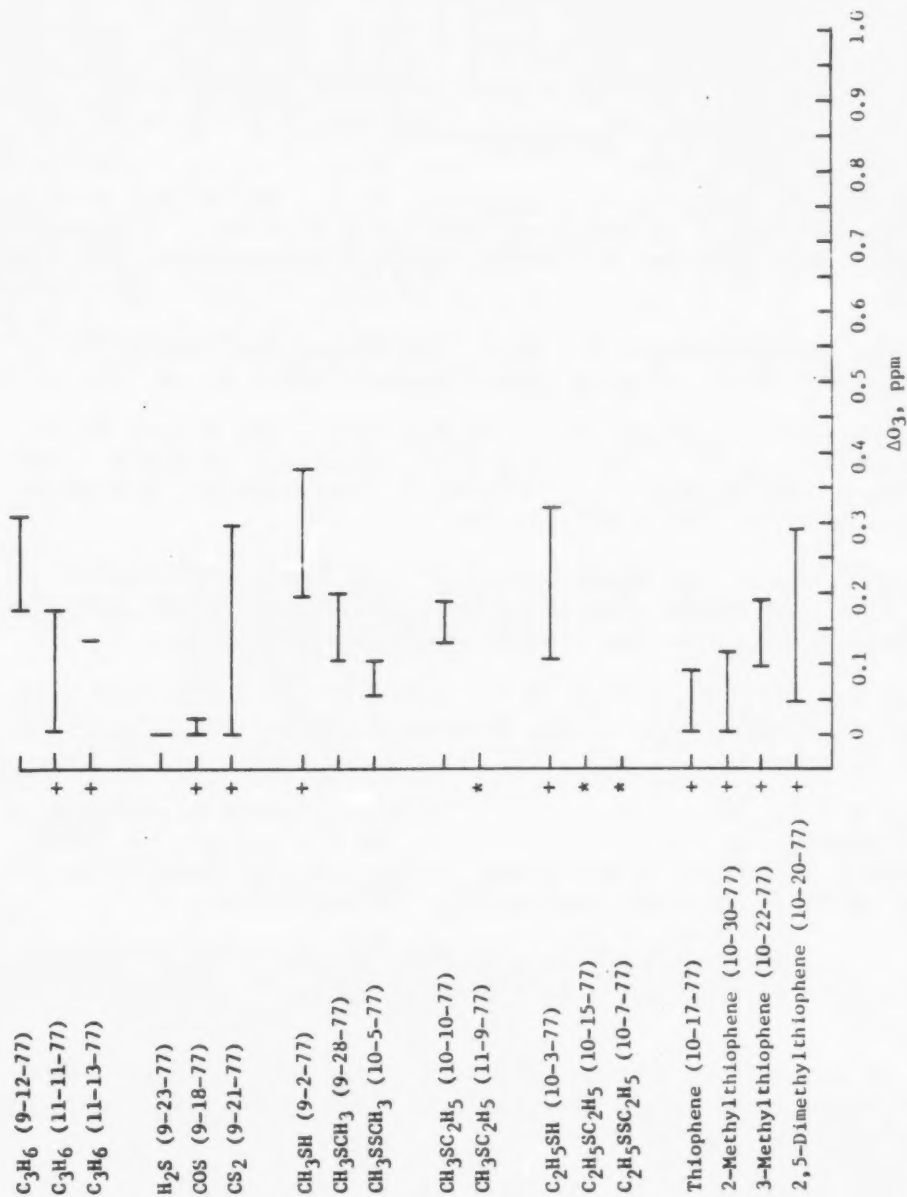


Figure 40. Range of second-day net ozone concentrations produced by each tested compound. (* indicates that the second-day CU-SR was less than 200 cal cm⁻²; and + indicates that in at least one case the second-day net ozone concentration exceeded the first-day maximum ozone concentration).

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APPENDIX
DETAILED DATA SHEETS FOR SMOG CHAMBER EXPERIMENTS

NOTES

1. Data sheets are listed in chronological order; see Table 3 in the text for a summary of the experimental program.
2. Except where noted otherwise, the target initial concentration of the tested compound was 2.0 ppmC.
3. Blank spaces indicate that data are not available.
4. Measured zero values and negative outputs (resulting from instrumental zero drift) are designated as 0.0.
5. Values measured to be greater than zero, but less than 0.001 measurement units are indicated by 0.000.
6. For the total sulfur and SO₂ data: concentrations too small to be quantified are listed as 0.010; and those concentrations that exceed the linear range of the instrument are designated as 1.500.
7. Key:

SAROAD No.	Name	Units	Description
44201	Ozone	ppm	Ozone
42601	NO	ppm	Nitric oxide
42602	NO ₂	ppm	Nitrogen dioxide
42603	NO _x	ppm	Total nitrogen oxides
44301	PAN	ppm	Peroxyacetyl nitrate
43205	Prop	ppmV	Propene
42269	T-Sul	ppmS	Total sulfur
42402	H ₂ S	ppmS	Hydrogen sulfide
42404	COS	ppmS	Carbonyl sulfide
42403	CS ₂	ppmS	Carbon disulfide
43901	CH ₃ SH	ppmS	Methanethiol
42401	SO ₂	ppmS	Sulfur dioxide
12169	T-P-S	µg/m ³	Total particulate sulfur
31114	CN-5	K-CN/CM ³ *	Condensation nuclei (PDP=5)
62100	Temp	°Celsius	Hourly average ambient temperature
63301	SR	L/Min†	Total solar radiation
63300	CU-SR	Lang†	Cumulative total solar radiation

*To be read "Thousand condensation nuclei per cubic centimeter."

†L = Lang = Langley = CAL/CM²

RTI SMUG CHAMBER STUDY
USEPA CONTRACT NO. 68-02-2457

CHAMBER NO. 1
DAY 1, 8-26-77
RUN 23 1 CH₂SH₂/

55 % SUNSHINE

TIME (EST)	OZONE (PPM)	NO (PPM)	NO ₂ (PPM)	NO _x (PPM)	T-P-S (UG/M3)	CH-S (K-CH/CM3)	SR (L/MIN)	CU-SR (LANG)	TEMP (CELSIUS)
0.13	0.008	0.001	0.004	0.005			0.001	0.01	19.0
1.13	0.0	0.592	0.0	0.592			0.001	0.08	19.2
2.13	0.0	0.579	0.002	0.581			0.001	0.24	18.8
3.13	0.0	0.554 ^{b/}	0.101 ^{b/}	0.655 ^{b/}			0.005	0.78	18.2
4.13	0.0	0.575	0.072	0.647			0.101	1.63	18.2
5.13	0.0	0.408	0.228	0.635			0.340	43.22	19.6
6.13	0.0	0.342	0.290	0.632			0.613	32.08	21.4
7.13	0.003	0.189	0.395	0.584			0.613	56.72	21.4
8.13	0.025	0.075	0.464	0.540			0.780	70.16	23.1
9.13	0.572	0.005	0.169	0.174	372.4		0.677	116.16	23.9
10.13	0.541	0.0	0.048	0.048		14.000	0.810	157.08	25.0
11.13	0.560	0.0	0.040	0.040			0.837	207.11	26.2
12.13	0.526	0.0	0.041	0.041			0.673	256.05	26.8
13.13	0.413	0.002	0.039	0.041	116.9	11.000	0.643	296.19	27.4
14.13	0.394	0.003	0.035	0.038			0.754	335.64	28.3
15.13	0.361	0.003	0.033	0.036			0.485	378.76	28.2
16.13	0.335	0.004	0.030	0.034			0.182	405.52	27.3
17.13	0.312	0.004	0.029	0.034	59.8		0.027	415.23	25.7
18.13	0.291	0.004	0.026	0.031			0.0	416.64	23.5
19.13	0.273	0.004	0.026	0.031		11.000	0.0	416.64	22.7
20.13	0.258	0.003	0.027	0.031			0.0	416.64	22.4
21.13	0.241	0.003	0.027	0.030			0.0	416.64	21.9

a/ Target initial concentration: 5 ppm.

b/ Consider this value to be the interference-corrected initial concentration.

DAY 2, 8-27-77

49 % SUNSHINE

TIME (EST)	OZONE (PPM)	NO (PPM)	NO ₂ (PPM)	NO _x (PPM)	T-P-S (UG/M3)	CH-S (K-CH/CM3)	SR (L/MIN)	CU-SR (LANG)	TEMP (CELSIUS)
0.13	0.224	0.004	0.024	0.032			0.0	0.0	20.9
1.13	0.207	0.004	0.029	0.032			0.0	0.0	19.9
2.13	0.189	0.004	0.030	0.033			0.0	0.0	18.9
3.13	0.167	0.004	0.030	0.034			0.0	0.0	18.3
4.13	0.146	0.004	0.032	0.036			0.001	0.01	17.9
5.13	0.124	0.003	0.032	0.035			0.007	0.11	17.7
6.13	0.103	0.004	0.033	0.037			0.091	1.19	16.5
7.13	0.085	0.003	0.033	0.035		6.600	0.238	7.80	20.4
8.13	0.066	0.002	0.033	0.035			0.348	22.93	22.9
9.13	0.121	0.002	0.033	0.035			0.762	47.20	25.3
10.13	0.187	0.001	0.032	0.033			1.044	96.20	27.7
11.13	0.239	0.001	0.033	0.033			0.803	157.22	28.2
12.13	0.279	0.002	0.033	0.033			0.889	206.07	29.1
13.13	0.293	0.002	0.033	0.034			0.500	256.38	28.7
14.13	0.293	0.004	0.032	0.036			0.784	288.59	29.5
15.13	0.295	0.004	0.032	0.036			0.446	333.00	29.4
16.13	0.268	0.003	0.033	0.037			0.504	360.21	29.8
17.13	0.277	0.003	0.032	0.036			0.255	388.51	29.4
18.13	0.264	0.003	0.030	0.034			0.043	402.15	27.9
19.13	0.246	0.002	0.027	0.029			0.0	404.40	25.1
20.13	0.233	0.001	0.026	0.026			0.0	404.40	23.6
21.13	0.219	0.003	0.024	0.027	6.8	17.000	0.0	404.40	22.4
22.13	0.205	0.003	0.025	0.028			0.0	404.40	21.6

R11 SHUG CHAMBER STUDY
USEPA CONTRACT NO. 68-02-2437

CHAMBER NO. 2				55 % SUNSHINE			
DAY 1, 8-26-77							
RUN 23 1 C ₂ H ₅ SH ₂ /							
TIME (EST)	UZURE (PPM)	NO (PPM)	NO ₂ (PPM)	NOX (PPM)	I-P-5 (UG/H3)	EN-5 (K-CN/CM3)	
0.63	0.002	0.003	0.001	0.004			
1.30	0.0	0.500	0.0	0.500			
3.13	0.0	0.500	0.005	0.571			
6.97	0.0	0.505	0.090	0.635			
8.30	0.173	0.019	0.477	0.497			
8.97	0.300	0.016	0.302	0.390			
9.30	0.323	0.013	0.304	0.377			
10.30	0.300	0.009	0.344	0.345			
11.30	0.423	0.007	0.313	0.320	76.0	23.000	
12.30	0.507	0.006	0.293	0.299			
13.30	0.500	0.006	0.262	0.260			
14.30	0.506	0.005	0.233	0.230			
15.30	0.556	0.005	0.204	0.214	36.6	110.000	
16.30	0.552	0.004	0.183	0.187			
17.30	0.517	0.005	0.164	0.169			
18.30	0.474	0.005	0.151	0.156			
19.30	0.433	0.005	0.140	0.145	4.6	155.000	
20.30	0.401	0.004	0.131	0.135			
21.30	0.372	0.004	0.126	0.132			
22.30	0.366	0.003	0.122	0.125			
23.30	0.321	0.003	0.120	0.123			

a/ Target Initial concentration: 5 ppm.
b/ Data are insufficient to permit correction for interference.

DAY 2, 8-27-77				49 % SUNSHINE			
TIME (EST)	UZURE (PPM)	NO (PPM)	NO ₂ (PPM)	NOX (PPM)	I-P-5 (UG/H3)	EN-5 (K-CN/CM3)	
0.30	0.298	0.004	0.118	0.122			
1.30	0.274	0.004	0.116	0.120			
2.30	0.250	0.004	0.116	0.120			
3.30	0.224	0.004	0.117	0.121			
4.30	0.200	0.004	0.116	0.120			
5.30	0.176	0.004	0.115	0.119			
6.30	0.155	0.004	0.117	0.121			
7.30	0.141	0.003	0.119	0.122			
8.30	0.153	0.002	0.121	0.123			
9.30	0.201	0.002	0.121	0.123			
10.30	0.231	0.001	0.122	0.123			
11.30	0.254	0.002	0.120	0.122			
12.30	0.263	0.002	0.120	0.122			
13.30	0.297	0.003	0.115	0.118			
14.30	0.263	0.004	0.112	0.116			
15.30	0.249	0.004	0.108	0.112			
16.30	0.240	0.003	0.103	0.106			
17.30	0.244	0.003	0.097	0.100			
18.30	0.220	0.003	0.089	0.092			
19.30	0.195	0.002	0.083	0.085			
20.30	0.173	0.002	0.076	0.078			
21.30	0.152	0.003	0.073	0.076	0.0	107.000	
22.30	0.155	0.003	0.070	0.073			

RTI SMUG CHAMBER STUDY
USEPA CONTRACT NO. 68-02-2437

CHAMBER NO. 3
DAY 1, 8-26-77
RUN 23 1 CH₂SH₂/

55 % SUNSHINE

TIME (EST)	UZONE (PPH)	NO (PPH)	NO ₂ (PPH)	NOX (PPH)	T-P-S (UG/H3) (K-CN/CH3)	CN-S (K-CN/CH3)	SR (L/MIN)	CU-SR (LANG)	TEMP CELSIUS
0.70	0.041	0.002	0.006	0.008			0.001	0.04	19.0
1.63	0.0	0.561	0.0	0.561			0.003	0.17	19.2
3.47	0.0	0.548	0.048	0.596			0.002	0.16	18.2
6.00	0.0	0.536	0.124	0.660			0.101	5.69	18.2
7.13	0.0	0.489	0.172	0.661			0.340	9.55	19.6
8.47	0.004	0.161	0.442	0.603			0.613	44.59	21.4
9.47	0.498	0.007	0.250	0.266			0.780	86.08	23.1
10.47	0.702	0.0	0.057	0.057	232.8		0.677	129.97	23.9
11.47	0.656	0.0	0.038	0.038		12.000	0.618	174.57	25.0
12.47	0.604	0.0	0.042	0.042			0.637	224.18	26.2
13.47	0.561	0.001	0.041	0.042			0.673	269.78	26.8
14.47	0.519	0.003	0.037	0.040			0.643	309.31	27.4
15.47	0.483	0.002	0.036	0.038	91.9	8.800	0.754	351.02	28.3
16.47	0.453	0.003	0.032	0.035			0.485	388.68	28.2
17.47	0.425	0.004	0.031	0.035			0.182	409.23	27.3
18.47	0.407	0.003	0.030	0.033			0.027	415.78	25.7
19.47	0.387	0.004	0.028	0.033	40.0		0.0	416.64	23.5
20.47	0.370	0.004	0.026	0.031		20.000	0.0	416.64	22.2
21.47	0.354	0.004	0.025	0.030			0.0	416.64	22.7
22.47	0.339	0.003	0.027	0.030			0.0	416.64	22.4
23.47	0.322	0.003	0.027	0.030			0.0	416.64	21.9

2/ Target initial concentration: 5 ppm; experiment employed ambient air with no prior purification.
b/ Data are insufficient to permit correction for interference.

DAY 2, 8-27-77

49 % SUNSHINE

TIME (EST)	UZONE (PPH)	NO (PPH)	NO ₂ (PPH)	NOX (PPH)	T-P-S (UG/H3) (K-CN/CH3)	CN-S (K-CN/CH3)	SR (L/MIN)	CU-SR (LANG)	TEMP CELSIUS
0.47	0.307	0.004	0.026	0.029			0.0	0.0	20.9
1.47	0.291	0.004	0.028	0.031			0.0	0.0	19.9
2.47	0.271	0.004	0.030	0.033			0.0	0.0	18.9
3.47	0.250	0.004	0.031	0.035			0.0	0.0	18.3
4.47	0.228	0.004	0.033	0.037			0.001	0.03	17.9
5.47	0.205	0.004	0.035	0.039			0.007	0.26	17.7
6.47	0.182	0.002	0.038	0.040			0.091	3.05	18.5
7.47	0.166	0.002	0.038	0.040			0.258	12.65	20.4
8.47	0.170	0.002	0.036	0.038		10.100	0.348	30.03	22.9
9.47	0.197	0.001	0.033	0.034			0.782	63.15	25.3
10.47	0.250	0.001	0.033	0.034			1.049	117.60	27.7
11.47	0.290	0.001	0.034	0.034			0.803	173.60	28.2
12.47	0.324	0.001	0.034	0.034			0.889	224.21	29.1
13.47	0.327	0.003	0.034	0.037			0.500	266.58	28.7
14.47	0.332	0.004	0.034	0.038			0.784	304.59	29.5
15.47	0.332	0.004	0.033	0.037			0.446	342.10	29.4
16.47	0.326	0.003	0.033	0.037			0.504	370.49	29.8
17.47	0.317	0.003	0.031	0.035			0.255	393.71	29.4
18.47	0.303	0.002	0.030	0.032			0.043	403.03	27.4
19.47	0.288	0.002	0.027	0.029			0.0	404.40	25.1
20.47	0.275	0.001	0.026	0.027	4.4		0.0	404.40	23.6
21.47	0.264	0.003	0.025	0.026		26.000	0.0	404.40	22.4
22.47	0.252	0.002	0.025	0.027			0.0	404.40	21.6

RTI SMUG CHAMBER STUDY
USEPA CONTRACT NO. 68-02-2437

CHAMBER NO. 4
DAY 1, 8-26-77
RUN 23 1 CH₂SHINE/
55 X SUNSHINE

TIME (EST)	OZONE (PPH)	NO (PPH)	NO ₂ (PPH)	NOX (PPH)	1-P-5 (UG/M3)	CN-5 (K-CN/CH3)	SR (L/MIN)	CU-SH (LANG)	TEMP CELSIUS
1.97	0.0	0.555	0.032	0.587			0.003	0.23	19.2
3.63	0.0	0.542	0.047	0.589			0.002	0.36	18.2
4.47	0.0	0.531	0.054	0.545			0.002	0.46	17.6
4.80	0.0	0.553	0.030	0.583			0.002	0.52	17.6
7.33	0.0	0.336	0.248	0.636			0.340	13.63	19.6
8.63	0.274	0.017	0.425	0.442			0.613	50.47	21.4
9.63	0.157	0.010	0.352	0.362			0.780	93.56	23.1
10.63	0.394	0.008	0.328	0.336	103.1		0.677	136.47	23.9
11.63	0.444	0.007	0.312	0.319			0.616	182.42	25.0
12.63	0.518	0.005	0.289	0.294	90.6	58.000	0.637	232.22	26.2
13.63	0.532	0.006	0.260	0.266			0.673	276.24	26.8
14.63	0.535	0.005	0.231	0.236			0.643	315.48	27.4
15.63	0.548	0.005	0.209	0.214	26.3	86.000	0.754	358.26	28.3
16.63	0.530	0.005	0.184	0.189			0.485	393.33	28.2
17.63	0.486	0.006	0.169	0.175			0.182	410.98	27.3
18.63	0.446	0.005	0.154	0.159			0.027	416.04	25.7
19.63	0.407	0.005	0.145	0.150			0.0	416.64	23.5
20.63	0.378	0.004	0.139	0.143	0.0	185.000	0.0	416.64	22.2
21.63	0.352	0.004	0.133	0.137			0.0	416.64	22.7
22.63	0.328	0.003	0.131	0.134			0.0	416.64	22.4
23.63	0.305	0.004	0.127	0.131			0.0	416.64	21.9

4/ Target Initial concentration: 5 ppm; experiment employed ambient air with no prior purification.
5/ Data are insufficient to permit correction for interference.

DAY 2, 8-27-77
49 X SUNSHINE

TIME (EST)	OZONE (PPH)	NO (PPH)	NO ₂ (PPH)	NOX (PPH)	1-P-5 (UG/M3)	CN-5 (K-CN/CH3)	SR (L/MIN)	CU-SH (LANG)	TEMP CELSIUS
0.63	0.283	0.004	0.123	0.127			0.0	0.0	20.9
1.63	0.261	0.004	0.122	0.126			0.0	0.0	19.9
2.63	0.241	0.004	0.121	0.125			0.0	0.0	18.9
3.63	0.219	0.004	0.121	0.125			0.0	0.0	18.3
4.63	0.197	0.004	0.120	0.124			0.001	0.04	17.9
5.63	0.177	0.004	0.121	0.125			0.007	0.32	17.7
6.63	0.159	0.003	0.120	0.123			0.091	3.92	18.5
7.63	0.151	0.003	0.121	0.124		112.000	0.238	14.94	20.4
8.63	0.170	0.002	0.123	0.125			0.348	33.37	22.9
9.63	0.241	0.001	0.125	0.126			0.782	70.66	25.3
10.63	0.304	0.002	0.123	0.125			1.049	127.67	27.7
11.63	0.478	0.001	0.121	0.122			0.803	181.31	28.2
12.63	0.572	0.002	0.121	0.123			0.889	232.74	29.1
13.63	0.569	0.003	0.115	0.116			0.500	271.38	28.7
14.63	0.623	0.004	0.113	0.117			0.784	312.11	29.5
15.63	0.634	0.003	0.108	0.112			0.446	346.38	29.4
16.63	0.634	0.003	0.103	0.106			0.504	375.33	29.6
17.63	0.623	0.003	0.096	0.099			0.255	396.16	29.4
18.63	0.597	0.002	0.089	0.091			0.043	403.44	27.4
19.63	0.571	0.002	0.083	0.085			0.0	404.40	25.1
20.63	0.550	0.002	0.078	0.080			0.0	404.40	23.6
21.63	0.532	0.003	0.074	0.077		83.000	0.0	404.40	22.4
22.63	0.512	0.003	0.072	0.075	0.0		0.0	404.40	21.6

REL. LAB. CONTROL STUDY USPFC CONTROL 100, 60-02-2037

Controlled by 1
DAY 1, 9-2-77
1000 272 40330

92 & 30050104

TIME (L.S.)	012.04 (PPH)	01 (PPH)	012 (PPH)	008 (PPH)	1-SUL (PPH)	502 (PPH)	0125H (PPH)	1-P-5 (UG/M3)	60-5 (K-CN/CM3)	SR (L/MIN)	CU-SR (LANG)	TEMP (CELLSIUS)
0-15	0.0	0.002	0.002	0.004	0.0	0.0	0.0			0.0	0.0	22.5
2-15	0.0	0.106	0.0	0.100	0.0	0.0	0.0			0.0	0.0	19.5
3-47	0.0	0.106	0.040	0.206	0.0	0.0	0.0			0.0	0.0	18.8
5-15	0.0	0.104	0.019	0.200	1.500	0.0	1.500	0.0		0.003	0.02	17.6
6-15	0.0	0.101	0.019	0.200	1.500	0.0	1.500	0.0		0.004	0.01	18.2
7-15	0.0	0.145	0.020	0.201	1.500	0.0	1.500	0.0		0.344	0.50	21.6
8-15	0.004	0.066	0.124	0.190	1.500	0.274	1.551	251.4	25.000	0.633	31.40	24.2
9-15	0.101	0.015	0.111	0.124	1.500	1.050	0.452		22.500	0.909	71.53	26.2
10-15	0.352	0.007	0.048	0.055	1.500	1.486	0.107			1.171	126.11	27.8
11-15	0.591	0.004	0.025	0.029	1.500	1.500	0.0	151.5		0.659	194.38	29.0
12-15	0.509	0.004	0.018	0.022	1.501	1.552	0.0		15.700	0.667	233.98	29.6
13-15	0.544	0.003	0.017	0.020	1.195	1.254	0.010			1.193	278.10	31.5
14-15	0.522	0.003	0.017	0.019	1.156	1.255	0.0			0.579	344.90	31.1
15-15	0.505	0.003	0.015	0.018	1.129	1.228	0.0			0.766	381.25	32.2
16-15	0.274	0.002	0.010	0.010	1.118	1.280	0.0			0.516	426.30	32.0
17-15	0.253	0.003	0.013	0.017	1.026	1.187	0.0			0.216	454.92	30.9
18-15	0.257	0.004	0.012	0.016	1.008	1.154	0.0	56.1		0.024	466.59	28.7
19-15	0.217	0.003	0.012	0.014	0.954	1.056	0.0			0.0	467.64	25.1
20-15	0.197	0.003	0.011	0.014	0.874	0.952	0.0			0.0	467.64	24.7
21-15	0.175	0.003	0.011	0.014	0.790	0.839	0.0			0.0	467.64	22.6
22-15	0.154	0.0	0.011	0.011	0.676	0.717	0.0			0.0	467.64	22.1
23-15	0.134	0.0	0.011	0.011	0.510	0.528	0.0			0.0	467.64	21.9

Consider this value to be the interference-corrected initial concentration.

DAY 2, 9-3-77

NO & 30050104

TIME (L.S.)	012.04 (PPH)	01 (PPH)	012 (PPH)	008 (PPH)	1-SUL (PPH)	502 (PPH)	0125H (PPH)	1-P-5 (UG/M3)	60-5 (K-CN/CM3)	SR (L/MIN)	CU-SR (LANG)	TEMP (CELLSIUS)
0-15	0.115	0.0	0.011	0.011	0.545	0.545				0.0	0.0	21.5
1-15	0.096	0.006	0.012	0.012	0.218					0.0	0.0	21.1
2-15	0.084	0.001	0.013	0.014						0.0	0.0	20.7
3-15	0.073	0.002	0.014	0.019						0.0	0.0	20.4
4-15	0.062	0.003	0.010	0.019						0.002	0.02	20.3
5-15	0.055	0.003	0.017	0.020				2.7		0.086	0.01	20.4
6-15	0.046	0.003	0.010	0.021					80.000	0.336	8.02	21.6
7-15	0.037	0.002	0.025	0.027						0.614	50.55	24.7
8-15	0.149	0.003	0.025	0.025						0.884	69.50	27.5
9-15	0.275	0.001	0.021	0.022						1.076	123.03	29.5
10-15	0.247	0.001	0.019	0.020						1.143	108.92	31.1
11-15	0.275	0.001	0.019	0.020						1.072	256.94	31.0
12-15	0.275	0.001	0.010	0.019						1.201	322.27	32.8
13-15	0.275	0.001	0.010	0.020						0.954	592.40	33.4
14-15	0.271	0.002	0.010	0.020						0.748	448.03	33.5
15-15	0.275	0.004	0.017	0.021				0.0	1.050	0.508	491.04	32.9
16-15	0.275	0.003	0.010	0.022				5.4	0.530	0.176	518.95	31.6
17-15	0.275	0.007	0.014	0.021						0.012	526.33	29.7
18-15	0.275	0.007	0.011	0.018						0.0	526.96	27.8
19-15	0.275	0.007	0.010	0.017						0.0	526.96	26.7
20-15	0.275	0.007	0.010	0.016						0.0	526.96	25.8
21-15	0.275	0.007	0.009	0.016				5.8		0.0	526.96	24.8
22-15	0.275	0.005	0.008	0.015						0.0	526.96	24.0

NET 5000, CHARTER STUDY
USFPA CONTRACT NO. 68-02-2437

CONC. OF CHLORINE
DAY 1, 9-2-77
NO. 2, 2-4-500

92 & SURVIVAL

TIME (LST)	0200L (PPH)	00 (PPH)	0002 (PPH)	0004 (PPH)	1-50L (PPH)	50L2 (PPH)	CHSSH (PPH)	1-P-S (UG/M3)	CH-S (K-CH/CH3)	SR (L/MIN)	CU-SR (LANG)	TEMP CELSIUS
0.30	0.0	0.002	0.003	0.005	0.0	0.0	0.0			0.0	0.0	22.3
2.47	0.0	0.002	0.003	0.005	0.0	0.0	0.0			0.0	0.0	19.5
3.30	0.0	0.002	0.003	0.005	0.0	0.0	0.0			0.0	0.0	18.0
5.30	0.0	0.100	0.0	0.100	0.0	0.0	0.0	10.0		0.003	0.05	17.0
6.30	0.0	0.075	0.005	0.098	1.500	0.0	1.500			0.098	1.67	16.2
7.30	0.0	0.067	0.038	0.106	1.500	0.010	1.500			0.144	12.01	21.0
8.30	0.032	0.024	0.073	0.071	1.500	0.296	1.470		34.000	0.633	37.05	24.2
9.30	0.158	0.016	0.055	0.071	1.500	0.760	0.965	180.2	26.000	0.909	60.80	26.2
10.30	0.290	0.015	0.034	0.040	1.500	1.100	0.653			1.171	140.06	27.0
11.30	0.265	0.014	0.025	0.037	1.500	1.390	0.475	75.0	16.300	0.659	201.10	29.0
12.30	0.261	0.013	0.010	0.029	1.500	1.172	0.276			0.667	240.79	29.0
13.30	0.297	0.011	0.009	0.026	1.500	1.259	0.242			1.193	290.27	31.3
14.30	0.260	0.011	0.006	0.010	1.500	1.354	0.211			0.579	350.80	31.1
15.30	0.265	0.010	0.005	0.010	1.500	1.331	0.185			0.786	369.27	32.2
16.30	0.250	0.009	0.000	0.015	1.500	1.387	0.275			0.516	431.57	32.0
17.30	0.232	0.011	0.004	0.015	1.500	1.333	0.175	5.5	5.700	0.216	457.13	30.9
18.30	0.215	0.011	0.001	0.012	1.500	1.276	0.162			0.024	466.63	28.7
19.30	0.190	0.010	0.002	0.011	1.483	1.175	0.153			0.0	467.64	25.1
20.30	0.175	0.008	0.002	0.010	1.325	0.900	0.120			0.0	467.64	24.7
21.30	0.155	0.009	0.002	0.011	1.159	0.779				0.0	467.64	22.0
22.30	0.135	0.008	0.004	0.012	0.892	0.467				0.0	467.64	22.1
23.30	0.114	0.009	0.005	0.014	0.630					0.0	467.64	21.9

af Consider this value to be the interference-corrected initial concentration.

DAY 2, 9-3-77

80 & SURVIVAL

TIME (LST)	0200L (PPH)	00 (PPH)	0002 (PPH)	0004 (PPH)	1-50L (PPH)	50L2 (PPH)	CHSSH (PPH)	1-P-S (UG/M3)	CH-S (K-CH/CH3)	SR (L/MIN)	CU-SR (LANG)	TEMP CELSIUS
0.30	0.095	0.009	0.006	0.015	0.528					0.0	0.0	21.3
1.30	0.077	0.007	0.008	0.015	0.485					0.0	0.0	21.1
2.30	0.062	0.007	0.007	0.016	0.450					0.0	0.0	21.1
3.30	0.048	0.008	0.011	0.019	0.435					0.0	0.0	20.7
4.30	0.035	0.009	0.011	0.020	0.517					0.0	0.0	20.9
5.30	0.025	0.009	0.013	0.022	0.503					0.002	0.04	20.3
6.30	0.013	0.010	0.014	0.024	0.467					0.088	1.70	20.4
7.30	0.017	0.010	0.023	0.033	0.510			0.0	52.000	0.336	11.45	21.6
8.30	0.080	0.006	0.027	0.035	0.476			14.7	52.000	0.614	36.61	24.7
9.30	0.195	0.009	0.027	0.031	0.451					0.804	78.31	27.3
10.30	0.261	0.002	0.021	0.023	0.430					1.076	134.61	29.5
11.30	0.355	0.001	0.010	0.019	0.412					1.143	200.57	31.1
12.30	0.300	0.002	0.017	0.019	0.400					1.072	267.88	31.8
13.30	0.374	0.002	0.017	0.019	0.359					1.201	334.52	32.8
14.30	0.367	0.002	0.010	0.010	0.271					0.954	402.13	33.4
15.30	0.330	0.002	0.017	0.019	0.231			16.7	1.240	0.748	455.66	33.3
16.30	0.350	0.004	0.017	0.021	0.234					0.508	496.22	32.9
17.30	0.367	0.007	0.014	0.021	0.226			7.9	0.480	0.178	520.76	31.6
18.30	0.353	0.007	0.011	0.016						0.012	528.46	29.7
19.30	0.339	0.007	0.000	0.015						0.0	528.96	27.6
20.30	0.320	0.007	0.000	0.015						0.0	528.96	26.7
21.30	0.317	0.007	0.007	0.014						0.0	528.96	25.0
22.30	0.336	0.007	0.007	0.014				4.6		0.0	528.96	24.0
23.30	0.290	0.005	0.006	0.011						0.0	528.96	24.0

RTI 5406 CHROMER STUDY
USDA Contract 60, 68-02-2437

CHROMER, 00, 5
DAY 1, 9-2-77
100, 2's : 0.0330

92 & 500SHINE

TIME (EST)	0200R (PPH)	00 (PPH)	002 (PPH)	004 (PPH)	1-50L (PPH)	502 (PPH)	CHSSH (PPH)	1-P-S (00/103)	(N-5) (K-CN/CH3)	SR (L/MIN)	CU-SR (LANG)	TEMP (CELSIUS)
0.47	0.0	0.001	0.002	0.003	0.0	0.0	0.0			0.0	0.0	22.3
1.47	0.0	0.796	0.0	0.796	0.0	0.0	0.0			0.0	0.0	20.5
2.47	0.0	0.784	0.0	0.994	0.0	0.0	0.0			0.0	0.0	19.5
4.47	0.0	0.787	0.202	0.968	1.500	0.0	1.500			0.0	0.0	16.2
5.47	0.0	0.774	0.210	0.983	1.500	0.0	1.500			0.003	0.08	17.6
6.47	0.0	0.743	0.229	0.973	1.500	0.0	1.500	34.5		0.094	2.83	18.2
7.47	0.0	0.553	0.018	0.951	1.500	0.276	1.218			0.344	15.52	21.6
8.47	0.037	0.126	0.656	0.764	1.500	1.624	0.120		39.000	0.633	40.31	24.2
9.47	0.130	0.021	0.469	0.510	1.252	1.183	0.0	498.9	30.000	0.909	90.07	26.2
10.47	0.234	0.006	0.290	0.296	1.165	1.202	0.0			1.171	152.00	27.8
11.47	0.350	0.002	0.135	0.137	1.111	1.172	0.0			0.659	207.82	29.0
12.47	0.327	0.002	0.052	0.054	0.899	0.906	0.0	197.3	15.000	0.667	247.59	29.6
13.47	0.403	0.002	0.043	0.046	0.763	0.861	0.0			1.193	302.44	31.3
14.47	0.479	0.001	0.037	0.030	0.776	0.861	0.0			0.579	356.71	31.1
15.47	0.403	0.001	0.031	0.032	0.759	0.849	0.0			0.786	397.28	32.2
16.47	0.447	0.002	0.031	0.033	0.726	0.837	0.0			0.516	436.83	32.0
17.47	0.431	0.004	0.030	0.033					7.100	0.216	459.33	30.9
18.47	0.414	0.003	0.026	0.030	0.664	0.744	0.0	36.2		0.024	466.88	28.7
19.47	0.392	0.002	0.026	0.028	0.588	0.675	0.0			0.0	467.64	25.1
20.47	0.367	0.002	0.026	0.028	0.565	0.612	0.0			0.0	467.64	24.7
21.47	0.345	0.001	0.026	0.026	0.492	0.535	0.0			0.0	467.64	22.6
22.47	0.323	0.000	0.026	0.026	0.398	0.432	0.0			0.0	467.64	22.1
23.47	0.302	0.0	0.026	0.026						0.0	467.64	21.9

Interference-corrected initial [NO], [NO₂], and [NO_x] are 0.798, 0.212, and 1.010 ppm.

DAY 2, 9-3-77

80 & 500SHINE

TIME (EST)	0200R (PPH)	00 (PPH)	002 (PPH)	004 (PPH)	1-50L (PPH)	502 (PPH)	CHSSH (PPH)	1-P-S (00/103)	(N-5) (K-CN/CH3)	SR (L/MIN)	CU-SR (LANG)	TEMP (CELSIUS)
0.47	0.281	0.001	0.029	0.030	0.296	0.306				0.0	0.0	21.3
1.47	0.262	0.001	0.030	0.031	0.218	0.220				0.0	0.0	21.1
2.47	0.247	0.000	0.032	0.033						0.0	0.0	21.1
3.47	0.231	0.001	0.032	0.033						0.0	0.0	20.7
4.47	0.217	0.002	0.034	0.036						0.0	0.0	20.4
5.47	0.201	0.002	0.036	0.036						0.002	0.06	20.3
6.47	0.181	0.003	0.036	0.041					83.000	0.068	2.60	20.4
7.47	0.171	0.003	0.042	0.045						0.336	14.88	21.6
8.47	0.191	0.001	0.041	0.042						0.614	42.67	24.7
9.47	0.230	0.001	0.039	0.040					92.000	0.884	67.33	27.3
10.47	0.274	0.001	0.030	0.037						1.076	145.78	29.5
11.47	0.313	0.001	0.033	0.034						1.143	212.23	31.1
12.47	0.337	0.000	0.042	0.043						1.072	278.01	31.8
13.47	0.351	0.002	0.031	0.033						1.201	346.77	32.8
14.47	0.336	0.002	0.030	0.032						0.954	411.66	33.4
15.47	0.350	0.003	0.029	0.032						0.748	463.29	33.3
16.47	0.353	0.005	0.029	0.034				3.6	0.530	0.508	501.40	32.9
17.47	0.345	0.007	0.020	0.035						0.178	522.58	31.6
18.47	0.353	0.007	0.021	0.031					0.200	0.012	528.58	29.7
19.47	0.341	0.007	0.021	0.026						0.0	528.96	27.8
20.47	0.312	0.007	0.020	0.027						0.0	528.96	26.7
21.47	0.303	0.006	0.020	0.026						0.0	528.96	25.8
22.47	0.296	0.006	0.020	0.026						0.0	528.96	24.8
23.47	0.290	0.004	0.019	0.023						0.0	528.96	24.0

RTI SHAW-WALKER STUDY
USLPA CONTRACT NO. 68-02-2437

CHARACTERISTICS
DAY 1, 9-2-77
R00, 25, 3, C0330

92 X SOLIDS

TIME (LST)	0204 (PPH)	00 (PPH)	002 (PPH)	004 (PPH)	1-SOL (PPH)	SOL (PPH)	CHSH (PPH)	1-P-S (UG/M3)	CH-5 (K-CH/CH3)	SR (L/MIN)	CU-SR (LANG) CELSIUS	TEMP CELSIUS
0.03	0.0	0.002	0.002	0.004	0.0	0.0	0.0			0.0	0.0	22.3
1.47	0.0	0.405	0.0	0.405	0.0	0.0	0.0			0.0	0.0	20.5
3.13	0.0	0.003	0.003	0.003	0.0	0.0	0.0			0.0	0.0	16.6
4.03	0.0	0.477	0.003	0.500	1.500	0.0	1.500			0.0	0.0	18.2
5.03	0.0	0.405	0.000	0.553	1.500	0.0	1.500			0.003	0.11	17.6
6.03	0.0	0.405	0.103	0.550	1.500	0.0	1.500			0.004	3.73	16.2
7.03	0.0	0.352	0.205	0.556	1.500	0.101	1.400	176.5	51.000	0.344	18.62	24.2
8.03	0.022	0.104	0.573	0.496	1.500	0.712	0.407			0.633	50.39	24.2
9.03	0.504	0.002	0.130	0.140	1.130	1.149	0.0	159.7	22.000	0.909	98.80	26.2
10.03	0.591	0.003	0.035	0.030	1.004	1.121	0.0			1.171	163.24	27.8
11.03	0.571	0.003	0.020	0.029	1.005	1.064	0.0	202.6	9.800	0.659	214.15	29.0
12.03	0.541	0.002	0.002	0.029	0.998	1.021	0.0			0.607	253.99	29.6
13.03	0.519	0.003	0.025	0.029	0.740	0.001	0.0			1.193	313.90	31.3
14.03	0.492	0.002	0.025	0.027	0.710	0.003	0.0			0.579	462.27	31.1
15.03	0.470	0.002	0.022	0.023	0.712	0.007	0.0			0.766	404.63	32.2
16.03	0.450	0.002	0.023	0.025	0.660	0.803	0.0			0.516	441.78	32.0
17.03	0.432	0.004	0.021	0.025						0.210	461.40	30.9
18.03	0.412	0.004	0.019	0.024	0.540	0.595	0.0	23.1	2.800	0.024	467.11	28.7
19.03	0.386	0.002	0.019	0.021	0.434	0.474	0.0			0.0	467.64	25.1
20.03	0.359	0.003	0.019	0.022	0.300	0.331	0.0			0.0	467.64	22.7
21.03	0.332	0.002	0.020	0.023						0.0	467.64	22.6
22.03	0.305	0.000	0.022	0.022						0.0	467.64	22.1
23.03	0.283	0.000	0.023	0.023						0.0	467.64	21.9

Consider this value to be the interference-corrected initial concentration.

DAY 2, 9-3-77

60 X SOLIDS

TIME (LST)	0204 (PPH)	00 (PPH)	002 (PPH)	004 (PPH)	1-SOL (PPH)	SOL (PPH)	CHSH (PPH)	1-P-S (UG/M3)	CH-5 (K-CH/CH3)	SR (L/MIN)	CU-SR (LANG) CELSIUS	TEMP CELSIUS
0.03	0.203	0.001	0.023	0.024						0.0	0.0	21.3
1.03	0.245	0.001	0.024	0.025						0.0	0.0	21.1
2.03	0.229	0.001	0.020	0.027						0.0	0.0	20.7
3.03	0.212	0.001	0.027	0.029						0.0	0.0	20.4
4.03	0.197	0.002	0.020	0.030						0.002	0.08	20.3
5.03	0.184	0.003	0.029	0.031						0.008	3.45	20.4
6.03	0.169	0.003	0.032	0.035						0.336	18.10	21.6
7.03	0.160	0.003	0.049	0.052						0.614	48.77	24.7
8.03	0.142	0.002	0.047	0.049						0.864	95.82	27.3
9.03	0.259	0.001	0.042	0.045						1.076	156.11	29.5
10.03	0.205	0.001	0.030	0.031						1.143	223.21	31.1
11.03	0.352	0.002	0.025	0.027						1.072	289.10	31.8
12.03	0.355	0.002	0.024	0.026						1.201	358.30	32.8
13.03	0.354	0.003	0.023	0.026						0.954	421.02	33.4
14.03	0.350	0.000	0.024	0.030						0.748	470.47	33.3
15.03	0.355	0.007	0.021	0.026						0.508	506.28	32.9
16.03	0.325	0.007	0.010	0.025						0.178	524.29	31.6
17.03	0.312	0.007	0.010	0.023						0.012	528.69	29.7
18.03	0.304	0.007	0.010	0.022						0.0	528.96	26.7
19.03	0.296	0.008	0.014	0.022						0.0	528.96	25.8
20.03	0.289	0.007	0.014	0.021						0.0	528.96	24.8
21.03	0.283	0.007	0.013	0.019						0.0	528.96	24.0
22.03	0.259	0.003	0.013	0.018								
23.03	0.242	0.003	0.013	0.018								

CELL SUBS. CHAMBER STUDY
USLPA CONTRACT NO. 68-02-2057

CHAMBER NO. 1
DAY 1, 9-12-77
KID 21 & PROPHET 21
95 % SUNSHINE

TIME (LST)	0200H (PPH)	TD (PPH)	NO2 (PPH)	NOX (PPH)	PRUP (PPH)	CH-5 (K-CH/CM5)	SR (L/MIN)	CU-SR (LANG) CELSIUS	TEMP (LST)
1.15	0.002	0.005	0.056	0.062			0.001	0.07	12.3
2.15							0.001	0.13	12.0
3.15							0.001	0.19	11.7
4.15							0.002	0.26	11.8
5.15							0.002	0.38	12.2
6.15	0.0	0.155	0.057	0.192	0.742		0.002	0.46	12.2
7.15	0.001	0.122	0.065	0.195	0.757	0.450	0.072	1.04	12.3
8.15	0.047	0.051	0.145	0.175	0.668		0.285	7.02	15.2
9.15	0.352	0.066	0.119	0.125	0.421		0.636	26.86	18.3
10.15	0.521	0.008	0.098	0.106	0.217		0.884	66.96	20.9
11.15	0.503	0.010	0.101	0.110	0.106		1.078	121.51	22.3
12.15	0.515	0.010	0.099	0.110			1.168	187.05	23.2
13.15	0.547	0.011	0.098	0.109			1.207	256.47	24.3
14.15	0.576	0.008	0.100	0.106			1.112	330.31	24.8
15.15	0.599	0.009	0.090	0.106			0.968	396.95	24.8
16.15	0.604	0.010	0.097	0.107			0.725	453.13	24.8
17.15	0.504	0.008	0.093	0.101		0.210	0.448	494.47	25.2
18.15	0.554	0.006	0.084	0.091			0.150	519.03	23.7
19.15	0.516	0.003	0.079	0.082			0.001	526.87	20.1
20.15	0.503	0.003	0.072	0.076			0.0	526.42	17.4
21.15	0.489	0.0	0.069	0.069			0.0	526.42	16.3
22.15	0.473	0.0	0.060	0.060			0.0	526.42	15.3
23.15	0.460	0.000	0.065	0.065			0.001	526.42	14.6
								526.43	13.8

a/ Experiment employed ambient air with no prior purification.

DAY 2, 9-15-77
82 % SUNSHINE

TIME (LST)	0200H (PPH)	TD (PPH)	NO2 (PPH)	NOX (PPH)	PRUP (PPH)	CH-5 (K-CH/CM5)	SR (L/MIN)	CU-SR (LANG) CELSIUS	TEMP (LST)
0.15	0.449	0.001	0.065	0.064			0.001	0.01	13.0
1.15	0.437	0.001	0.061	0.062			0.003	0.00	13.1
2.15	0.420	0.000	0.060	0.060			0.002	0.26	13.3
3.15	0.418	0.001	0.059	0.060			0.002	0.38	12.7
4.15	0.410	0.001	0.058	0.060			0.002	0.50	12.2
5.15	0.400	0.000	0.055	0.055			0.003	0.62	11.8
6.15	0.392	0.001	0.055	0.057			0.064	1.28	12.0
7.15	0.381	0.002	0.055	0.056			0.280	6.80	14.8
8.15	0.371	0.002	0.057	0.059			0.600	26.10	16.3
9.15	0.365	0.003	0.063	0.066	0.0		0.858	64.11	21.9
10.15	0.384	0.009	0.067	0.076			1.055	117.13	23.8
11.15	0.418	0.007	0.066	0.075			1.163	181.27	24.9
12.15	0.470	0.007	0.060	0.075	0.0		1.179	251.18	26.1
13.15	0.515	0.007	0.067	0.074	0.0		1.094	321.25	27.1
14.15	0.554	0.007	0.060	0.073	0.0		0.922	385.55	27.3
15.15	0.570	0.007	0.064	0.071	0.0		0.696	439.11	27.4
16.15	0.580	0.008	0.069	0.068	0.0		0.407	478.61	27.1
17.15	0.560	0.007	0.059	0.062	0.0		0.186	501.00	25.9
18.15	0.544	0.007	0.050	0.057	0.0		0.006	508.67	22.9
19.15	0.516	0.005	0.045	0.050	0.0		0.0	508.48	21.9

KIT SMH, CHAMBER STUDY
USLPA CONTROL NO. 68-92-2437

CHAMBER NO. 2
DAY 1, 9-12-77
RHH 21 : PHOSPHOR μ /

95 & SUNSHINE

TIME (EST)	UZULH (PPH)	NO (PPH)	NO2 (PPH)	NOX (PPH)	PROP (PPH)	CH-5 (R-CH/CM3)	SR (L/MIN)	CU-SR (LANG)	TEMP CELSIUS
1.30							0.001	0.08	12.3
6.30							0.072	1.78	12.3
7.30							0.285	9.93	15.2
8.30	0.040	0.017	0.050	0.074	0.737	0.500	0.636	33.35	18.3
9.30	0.280	0.005	0.044	0.048	0.525		0.884	75.97	20.9
10.30	0.282	0.010	0.044	0.054	0.381		1.078	132.50	22.3
11.30	0.258	0.011	0.047	0.057	0.294		1.188	199.16	23.2
12.30	0.209	0.011	0.047	0.059			1.207	270.79	24.3
13.30	0.294	0.013	0.051	0.064			1.132	341.86	24.8
14.30	0.317	0.011	0.053	0.064			0.968	406.82	24.8
15.30	0.334	0.012	0.053	0.065		0.410	0.725	468.53	24.8
16.30	0.344	0.014	0.055	0.069			0.448	499.04	25.2
17.30	0.329	0.010	0.050	0.060			0.150	520.56	23.7
18.30	0.295	0.006	0.046	0.054			0.001	526.88	20.1
19.30	0.275	0.003	0.040	0.049			0.0	526.92	17.4
20.30	0.264	0.002	0.042	0.045			0.0	526.92	16.3
21.30	0.253	0.0	0.041	0.041			0.0	526.92	15.3
22.30	0.245	0.000	0.040	0.040			0.0	526.92	14.6
23.30	0.235	0.000	0.040	0.040			0.001	526.94	13.8

Experiment employed ambient air with no prior purification; due to an operational problem during reactant injection, the initial concentrations are not clearly defined.

DAY 2, 9-13-77

82 & SUNSHINE

TIME (EST)	UZULH (PPH)	NO (PPH)	NO2 (PPH)	NOX (PPH)	PROP (PPH)	CH-5 (R-CH/CM3)	SR (L/MIN)	CU-SR (LANG)	TEMP CELSIUS
0.30	0.225	0.001	0.037	0.038			0.001	0.02	13.0
1.30	0.217	0.0	0.037	0.037			0.003	0.11	13.1
2.30	0.212	0.000	0.037	0.037			0.002	0.28	13.3
3.30	0.205	0.002	0.036	0.038			0.002	0.40	12.7
4.30	0.199	0.001	0.035	0.036			0.002	0.52	12.2
5.30	0.194	0.000	0.034	0.034			0.003	0.65	11.8
6.30	0.186	0.002	0.034	0.036			0.064	1.93	12.0
7.30	0.160	0.002	0.035	0.037			0.280	9.66	14.8
8.30	0.176	0.003	0.039	0.042			0.600	32.22	16.3
9.30	0.187	0.007	0.043	0.050	0.0		0.858	72.86	21.9
10.30	0.225	0.011	0.046	0.057			1.055	127.89	23.8
11.30	0.277	0.011	0.050	0.061			1.163	193.13	24.9
12.30	0.342	0.011	0.053	0.064	0.0		1.179	263.20	26.1
13.30	0.398	0.012	0.054	0.066	0.0		1.094	332.41	27.1
14.30	0.449	0.010	0.052	0.065	0.0		0.922	394.96	27.3
15.30	0.478	0.011	0.055	0.066	0.0		0.696	446.21	27.4
16.30	0.438	0.012	0.055	0.067	0.0		0.407	482.76	27.1
17.30	0.476	0.011	0.052	0.063			0.146	502.49	25.9
18.30	0.451	0.008	0.045	0.053	0.0		0.006	506.73	22.9
19.30	0.427	0.005	0.041	0.046	0.0		0.0	508.96	21.9

FILE 3406, CHAMBER STUDY
USEPA CHINIMACI INT. GR-02-2437

CHAMBER NO. 3
DAY 1, 9-10-77
RUN #1 & PRELIM #2

95 & SUNSHINE

TIME (LSI)	W2000 (PPM)	W2 (PPM)	W20 (PPM)	W200 (PPM)	W2000 (PPM)	W2 (PPM)	W20 (PPM)	W200 (PPM)	CH-S (R-CH/CH3)	SR (L/MIN)	CU-SR (LANG)	TEMP CELSIUS
1:07	0.002	0.004	0.007	0.051						0.001	0.09	12.3
2:07										0.001	0.15	12.0
3:07										0.001	0.21	11.7
4:07										0.002	0.30	11.8
5:03									0.590	0.002	0.44	12.2
6:07	0.0	0.752	0.202	0.954						0.072	2.51	12.3
7:07	0.0	0.727	0.211	0.939						0.265	12.64	15.2
8:07	0.0	0.659	0.250	0.910						0.636	39.64	18.3
9:07	0.0	0.551	0.359	0.910						0.684	84.99	20.9
10:07	0.002	0.365	0.474	0.815						1.078	143.50	22.3
11:07	0.023	0.100	0.597	0.757						1.186	211.28	23.2
12:07	0.175	0.017	0.648	0.684						1.207	283.10	24.3
13:07	0.450	0.014	0.542	0.557						1.132	353.40	24.0
14:07	0.093	0.012	0.400	0.420						0.968	416.70	24.8
15:07	0.073	0.012	0.249	0.311						0.725	467.92	24.8
16:07	0.073	0.011	0.247	0.250						0.448	503.61	25.2
17:07	0.070	0.010	0.220	0.210						0.150	522.09	23.7
18:07	0.005	0.005	0.198	0.194						0.001	526.89	20.1
19:07	0.004	0.004	0.185	0.169						0.0	526.92	17.4
20:07	0.011	0.002	0.175	0.177						0.0	526.92	16.3
21:07	0.001	0.001	0.167	0.168						0.0	526.92	15.3
22:07	0.009	0.001	0.163	0.164						0.001	526.95	14.6
23:07	0.072	0.008	0.168	0.168						0.001	526.95	13.8

218

of Experiment employed ambient air with no prior purification.

TIME (LSI)	W2000 (PPM)	W2 (PPM)	W20 (PPM)	W200 (PPM)	W2000 (PPM)	W2 (PPM)	W20 (PPM)	W200 (PPM)	CH-S (R-CH/CH3)	SR (L/MIN)	CU-SR (LANG)	TEMP CELSIUS
0:07	0.755	0.001	0.150	0.157						0.001	0.03	13.0
1:07	0.721	0.001	0.152	0.153						0.003	0.14	13.1
2:07	0.710	0.001	0.148	0.149						0.002	0.30	13.3
3:07	0.695	0.002	0.146	0.148						0.002	0.42	12.7
4:07	0.683	0.001	0.144	0.145						0.002	0.54	12.2
5:07	0.674	0.001	0.142	0.143						0.003	0.68	11.8
6:07	0.659	0.002	0.140	0.141						0.004	2.58	12.0
7:07	0.649	0.002	0.136	0.138						0.280	12.52	14.8
8:07	0.631	0.003	0.134	0.142						0.600	38.14	18.3
9:07	0.604	0.006	0.142	0.140						0.658	81.62	21.9
10:07	0.602	0.010	0.140	0.145						1.055	138.65	23.8
11:07	0.588	0.009	0.136	0.140						1.163	205.00	24.9
12:07	0.573	0.009	0.122	0.131						1.179	275.23	26.1
13:07	0.569	0.008	0.111	0.119						1.094	343.57	27.1
14:07	0.560	0.008	0.111	0.119						0.922	404.36	27.3
15:07	0.540	0.016	0.106	0.107						0.696	453.11	27.4
16:07	0.508	0.016	0.092	0.096						0.407	486.92	27.1
17:07	0.482	0.008	0.089	0.086						0.146	503.96	25.9
18:07	0.461	0.007	0.082	0.084						0.066	508.79	24.9
19:07	0.415	0.005	0.064	0.069						0.0	508.98	21.9

R11 SHUG, CHAMBER STUDY
USLPA CONTROL NO. 66-02-2037

CHAMBER NO. 8
DAY 1, 9-12-77
MON 2/ 3 PHOTOPHASE 2/

95 & SUNSHINE

TIME (EST)	OZONE (PPM)	NO (PPM)	NO2 (PPM)	NOX (PPM)	PHIP (PPM)	CN-5 (K-CN/CM3)	SH (L/MIN)	CU-SH (LANG) CELSIUS	TEMP CELSIUS
1.63	0.002	0.004	0.003	0.007	0.607	0.295	0.001	0.10	12.3
2.63					0.711		0.001	0.16	12.0
3.63					0.671		0.001	0.22	11.7
4.63					0.586		0.002	0.32	11.6
5.30	0.0	0.374	0.100	0.487	0.607		0.002	0.40	12.2
6.63	0.0	0.374	0.103	0.477	0.711		0.072	3.20	12.3
7.63	0.0	0.308	0.152	0.460	0.671		0.285	15.57	15.2
8.63	0.005	0.193	0.263	0.456	0.586		0.636	45.94	18.3
9.63	0.077	0.039	0.350	0.397	0.454		0.884	93.40	20.9
10.63	0.444	0.010	0.308	0.318	0.240		1.078	153.65	22.3
11.63	0.788	0.009	0.277	0.235	0.072		1.108	222.49	23.2
12.63	0.911	0.006	0.198	0.207			1.207	294.68	24.3
13.63	0.943	0.010	0.196	0.206			1.132	364.27	24.0
14.63	0.963	0.008	0.189	0.197			0.968	425.99	24.8
15.63	0.968	0.009	0.176	0.185		0.620	0.725	474.06	24.8
16.63	0.953	0.009	0.170	0.179			0.440	507.91	25.2
17.63	0.915	0.008	0.159	0.167			0.150	523.53	23.7
18.63	0.855	0.004	0.145	0.149			0.001	526.90	20.1
19.63	0.829	0.004	0.136	0.141			0.0	526.92	17.4
20.63	0.805	0.002	0.130	0.131			0.0	526.92	16.3
21.63	0.788	0.001	0.124	0.125			0.0	526.92	15.3
22.63	0.769	0.001	0.120	0.122			0.0	526.92	14.6
23.63	0.753	0.000	0.118	0.118			0.001	526.96	13.8

2/ Experiment employed ambient air with no prior purification.

DAY 2, 9-13-77

R2 & SUNSHINE

TIME (EST)	OZONE (PPM)	NO (PPM)	NO2 (PPM)	NOX (PPM)	PHIP (PPM)	CN-5 (K-CN/CM3)	SH (L/MIN)	CU-SH (LANG) CELSIUS	TEMP CELSIUS
0.63	0.736	0.001	0.114	0.115			0.001	0.04	13.0
1.63	0.722	0.001	0.112	0.113			0.003	0.17	13.1
2.63	0.710	0.000	0.110	0.110			0.002	0.32	13.3
3.63	0.696	0.001	0.107	0.108			0.002	0.44	12.7
4.63	0.684	0.001	0.103	0.104			0.002	0.56	12.2
5.63	0.671	0.001	0.102	0.104			0.003	0.71	11.8
6.63	0.657	0.002	0.101	0.102			0.004	1.20	12.0
7.63	0.647	0.002	0.103	0.105			0.008	15.20	14.8
8.63	0.638	0.003	0.104	0.107	0.0		0.000	44.10	16.3
9.63	0.633	0.006	0.107	0.113	0.0		0.000	89.05	21.9
10.63	0.624	0.000	0.108	0.110			0.058	148.78	23.8
11.63	0.604	0.007	0.105	0.112	0.0		1.055	216.16	24.9
12.63	0.594	0.007	0.101	0.108	0.0		1.163	286.55	26.1
13.63	0.581	0.007	0.094	0.101	0.0		1.179	354.07	27.1
14.63	0.561	0.007	0.088	0.091	0.0		1.094	413.21	27.3
15.63	0.548	0.008	0.074	0.082	0.0		0.922	459.99	27.4
16.63	0.536	0.008	0.069	0.077	0.0		0.696	499.82	27.4
17.63	0.524	0.007	0.061	0.068	0.0		0.487	505.38	25.9
18.63	0.514	0.007	0.054	0.061	0.0		0.146	506.85	22.9
19.63	0.510	0.005	0.054	0.054	0.0		0.006	506.98	21.9

RTI SMUG CHAMBER STUDY
USEPA CONTRACT NO. 68-02-2437

CHAMBER NO. 1
DAY 1, 9-18-77
RUN 29 1 CO3

77 X SUNSHINE

TIME (EST)	OZONE (PPM)	NO (PPM)	NO2 (PPM)	NOX (PPM)	T-SUL (PPM)	CO5 (PPM)	T-P-S (UG/M3)	CN-S (K-CN/CM3)	SR (L/MIN)	CU-SR (LANG)	TEMP CELSIUS
0.13	0.0	0.000	0.006	0.015					0.0	0.0	21.9
1.13									0.0	0.0	20.8
2.13									0.001	0.01	20.8
3.13	0.0	0.160 ^{a/}	0.048 ^{a/}	0.208 ^{a/}					0.001	0.02	19.7
4.13	0.0	0.159	0.046	0.204			0.0		0.004	0.15	20.0
5.13	0.0	0.157	0.047	0.204			0.0		0.005	0.21	20.2
6.13	0.0	0.155	0.048	0.203			0.0		0.218	0.92	20.4
7.13	0.0						0.0		0.218	15.29	20.9
7.05							0.0		0.567	21.76	22.0
8.13	0.001	0.159	0.043	0.202			0.0		0.783	57.02	23.1
9.13	0.001	0.162	0.039	0.200			0.0	0.100	1.005	106.18	21.2
10.13	0.002	0.161	0.035	0.196			0.0	1.300	0.921	165.02	20.1
11.13	0.002	0.159	0.032	0.191			0.0		1.193	223.21	20.3
12.13	0.002	0.154	0.034	0.180			0.0		1.078	293.89	20.6
13.13	0.002	0.153	0.037	0.190	1.500	1.500			0.701	355.63	20.1
14.13	0.001	0.150	0.039	0.189	1.500	1.500			0.668	397.43	20.1
15.13	0.002	0.151	0.041	0.192	1.500	1.500			0.398	435.40	20.1
16.13	0.001	0.140	0.042	0.191	1.500	1.500	0.0		0.108	457.02	20.9
17.13	0.001	0.142	0.042	0.184	1.500	1.500	0.0		0.005	462.70	23.1
18.13	0.0	0.136	0.041	0.177	1.500	1.500	0.0		0.0	462.96	23.2
19.13	0.0	0.136	0.042	0.178	1.500	1.500			0.0	462.96	21.9
20.13	0.0	0.120	0.042	0.170					0.0	462.96	21.7
21.13	0.0								0.0		
22.13	0.0	0.123	0.044	0.157	1.500	1.500	0.0		0.0	462.96	21.4
23.13	0.0	0.122	0.036	0.158	1.500	1.500			0.0		

^{a/} Consider this to be the interference-corrected initial concentration.

DAY 2, 9-19-77

74 X SUNSHINE

TIME (EST)	OZONE (PPM)	NO (PPM)	NO2 (PPM)	NOX (PPM)	T-SUL (PPM)	CO5 (PPM)	T-P-S (UG/M3)	CN-S (K-CN/CM3)	SR (L/MIN)	CU-SR (LANG)	TEMP CELSIUS
0.13	0.0	0.121	0.035	0.156	1.500	1.500			0.0	0.0	20.9
1.13	0.0	0.122	0.035	0.157	1.500	1.500			0.0	0.0	20.6
2.13	0.0	0.122	0.037	0.159	1.500	1.500			0.0	0.0	20.2
3.13	0.0	0.121	0.036	0.159	1.500	1.500			0.0	0.0	20.0
4.13	0.0	0.121	0.041	0.162	1.500	1.500			0.001	0.01	20.1
5.13	0.0	0.118	0.042	0.160	1.500	1.500	0.0		0.002	0.08	20.3
6.13	0.0	0.120	0.043	0.163	1.500	1.500			0.003	0.52	20.4
7.13	0.0	0.119	0.047	0.169	1.500	1.500			0.228	4.54	21.4
8.13	0.002	0.109	0.044	0.163	1.500	1.500			0.513	20.44	23.2
9.13	0.004	0.104	0.051	0.157	1.500	1.500			0.721	52.84	24.7
10.13	0.005	0.099	0.050	0.148	1.500	1.500			0.994	98.23	26.7
11.13	0.006	0.094	0.053	0.146	1.500	1.500			1.032	158.17	28.4
12.13	0.007	0.087	0.051	0.139	1.500	1.500	0.0		0.697	217.48	28.9
13.13					1.500	1.500			0.604	258.88	29.3
14.13	0.004	0.075	0.053	0.128	1.500	1.500		0.840	0.804	298.77	29.6
15.13	0.007	0.073	0.055	0.128	1.500	1.500			0.607	305.94	28.4
16.13	0.006	0.069	0.053	0.122	1.500	1.500			0.431	384.12	27.7
17.13	0.003	0.065	0.055	0.120	1.500	1.500		0.470	0.116	407.54	26.1

RTI SMOG CHAMBER STUDY
USEPA CONTRACT NO. 68-02-2437

CHAMBER NO. 2
DAY 1, 9-18-77
RUN 29 1 CUS

77 X SUNSHINE

TIME (EST)	OZONE (PPH)	NO (PPH)	NO ₂ (PPH)	NOX (PPH)	T-SUL (PPH)	CUS (PPH)	T-P-S (UG/M3)	CN-5 (K-CN/CM3)	SR (L/MIN)	CU-SR (LANG)	TEMP CELSIUS
0.30	0.0	0.008	0.007	0.015					0.0	0.0	21.4
1.30	0.0	0.079	0.020	0.098					0.0	0.0	20.8
3.47	0.0	0.077 ^{a/}	0.021 ^{a/}	0.098 ^{a/}					0.0	0.06	20.2
4.30	0.0	0.076	0.024	0.100			0.0	0.0	0.001	0.08	19.7
5.30	0.0	0.075	0.027	0.102			6.3	0.0	0.004	0.19	20.0
6.30	0.0	0.074	0.032	0.106			0.0	0.0	0.045	1.17	20.2
7.30	0.0	0.070	0.034	0.105			0.0	0.0	0.238	7.34	20.4
7.58	0.003	0.070	0.034	0.105			0.0	0.0	0.238	15.63	20.4
8.30	0.006	0.069	0.032	0.101			0.0	5.600	0.567	27.55	22.0
9.30	0.007	0.065	0.034	0.099			0.0	0.560	0.783	65.45	25.1
10.30	0.008	0.061	0.034	0.094			0.0		1.005	116.43	27.2
11.30	0.009	0.055	0.035	0.090			0.0		0.921	175.22	28.1
12.30	0.011	0.056	0.037	0.093	1.500	1.500			1.193	235.37	29.3
13.30	0.010	0.051	0.040	0.092	1.500	1.500			1.078	304.88	29.6
14.30	0.011	0.051	0.041	0.092	1.500	1.500	0.0		0.701	362.78	29.1
15.30	0.006	0.048	0.045	0.093	1.500	1.500		0.350	0.668	404.24	29.1
16.30	0.003	0.042	0.047	0.089	1.500	1.500			0.598	439.46	29.1
17.30	0.0	0.036	0.048	0.084	1.500	1.500			0.188	458.12	26.9
18.30	0.0	0.035	0.049	0.085	1.500	1.500	0.0		0.005	462.75	25.1
19.30	0.0	0.036	0.049	0.085	1.500	1.500			0.0	462.96	23.8
20.30	0.0	0.029	0.042	0.071	1.500	1.500		0.300	0.0	462.96	21.2
21.30	0.0	0.029	0.042	0.071	1.500	1.500			0.0	462.96	21.9
22.30	0.0								0.0	462.96	21.7
23.30	0.0								0.0	462.96	21.4

^{a/} Interference-corrected initial [NO], [NO₂], and [NO_x] are 0.071, 0.037, and 0.108 ppm.

DAY 2, 9-19-77

74 X SUNSHINE

TIME (EST)	OZONE (PPH)	NO (PPH)	NO ₂ (PPH)	NOX (PPH)	T-SUL (PPH)	CUS (PPH)	T-P-S (UG/M3)	CN-5 (K-CN/CM3)	SR (L/MIN)	CU-SR (LANG)	TEMP CELSIUS
0.30	0.0	0.029	0.042	0.071	1.500	1.500			0.0	0.0	20.9
1.30	0.0	0.031	0.042	0.073	1.500	1.500			0.0	0.0	20.6
2.30	0.0	0.031	0.044	0.075	1.500	1.500			0.0	0.0	20.2
3.30	0.0	0.032	0.045	0.077	1.500	1.500			0.0	0.0	20.0
4.30	0.0	0.031	0.040	0.079	1.500	1.500			0.001	0.02	20.1
5.30	0.0	0.030	0.050	0.080	1.500	1.500	0.0	0.0	0.002	0.10	20.3
6.30	0.0	0.034	0.051	0.085	1.500	1.500			0.043	0.95	20.4
7.30	0.004	0.036	0.051	0.087	1.500	1.500			0.228	6.86	21.4
8.30	0.009	0.037	0.046	0.083	1.500	1.500			0.513	25.67	23.2
9.30	0.015	0.036	0.041	0.077	1.500	1.500			0.721	60.20	24.7
10.30	0.019	0.035	0.039	0.074	1.500	1.500			0.994	108.37	26.7
11.30	0.024	0.032	0.037	0.069	1.500	1.500			1.032	168.70	28.4
12.30	0.025	0.027	0.040	0.067	1.500	1.500	0.0		0.697	224.59	28.9
13.30					1.500	1.500		0.0	0.644	265.45	29.3
14.30	0.028	0.023	0.036	0.060	1.500	1.500			0.804	306.97	29.6
15.30	0.028	0.021	0.040	0.060	1.500	1.500			0.667	352.75	28.4
16.30	0.026	0.019	0.041	0.060	1.500	1.500			0.431	388.52	27.7
17.30	0.018	0.013	0.045	0.058	1.500	1.500		0.0	0.118	408.74	26.1

RTI SMOG CHAMBER STUDY
USEPA CONTRACT NO. 68-02-2437

CHAMBER NO. 3
DAY 1, 9-18-77
RUN 29 : COS

77 X SUNSHINE

TIME (EST)	OZONE (PPM)	NO (PPM)	NO2 (PPM)	NOX (PPM)	T-SUL (PPM)	COS (PPM)	T-P-S (UG/M3)	CN-S (K-CN/CN3)	SP (L/MIN)	CU-SR (LANG)	TEMP CELSIUS
0.47	0.0	0.009	0.009	0.018					0.0	0.0	21.4
1.47	0.0	0.780	0.395 a,b/	1.175 a,b/					0.0	0.0	20.8
2.00	0.0	0.752	0.420 b/	1.172 b/					0.001	0.05	20.8
4.47	0.0	0.738	0.439 b/	1.176 b/			3.4		0.001	0.09	19.7
5.47	0.0	0.727	0.431 b/	1.157 b/			2.8	0.0	0.045	0.23	20.0
6.47	0.0	0.723	0.427 b/	1.150 b/			0.0	0.0	0.238	9.77	20.4
7.47	0.0							0.0	0.238	16.63	20.4
7.95	0.0	0.747	0.363	1.110			0.0		0.567	33.33	22.0
8.47	0.0	0.780	0.315	1.095				0.109	0.783	73.44	25.1
9.47	0.0	0.797	0.289	1.085			0.0	1.100	1.005	126.68	27.2
10.47	0.0	0.806	0.264	1.070			0.0		0.921	184.61	28.1
12.47	0.0	0.827	0.250	1.077	1.500	1.500			1.193	247.54	29.3
13.47	0.0	0.820	0.238	1.058	1.500	1.500			1.078	315.88	29.6
14.47	0.0	0.849	0.235	1.084	1.500	1.500			0.701	369.93	29.1
15.47	0.0	0.874	0.225	1.099	1.500	1.500	0.0	0.0	0.668	411.06	29.1
16.47	0.0	0.871	0.221	1.091	1.500	1.500			0.398	441.52	29.1
17.47	0.0	0.838	0.217	1.071	1.500	1.500			0.108	459.22	28.9
18.47	0.0	0.830	0.228	1.058	1.500	1.500	0.0		0.005	462.80	25.1
19.47	0.0	0.795	0.246	1.041	1.500	1.500			0.0	462.96	23.8
20.47	0.0	0.784	0.242	1.026	1.500	1.500		0.0	0.0	462.96	21.9
21.47	0.0								0.0	462.96	21.7
22.47	0.0	0.751	0.287	0.998	1.500	1.500			0.0	462.96	21.4
23.47	0.0	0.731	0.256	0.987	1.500	1.500					

a/ Interference-corrected Initial [NO], [NO2], and [NOx] are 0.787, 0.394, and 1.181 ppm.

b/ Instrument was overranged; data suspect.

DAY 2, 9-19-77

74 X SUNSHINE

TIME (EST)	OZONE (PPM)	NO (PPM)	NO2 (PPM)	NOX (PPM)	T-SUL (PPM)	COS (PPM)	T-P-S (UG/M3)	CN-S (K-CN/CN3)	SR (L/MIN)	CU-SR (LANG)	TEMP CELSIUS
0.47	0.0	0.714	0.264	0.978	1.500	1.500			0.0	0.0	20.9
1.47	0.0	0.701	0.270	0.971	1.500	1.500			0.0	0.0	20.6
2.47	0.0	0.693	0.293	0.986	1.500	1.500			0.0	0.0	20.2
3.47	0.0	0.697	0.287	0.983	1.500	1.500			0.0	0.0	20.0
4.47	0.0	0.681	0.305	0.986	1.500	1.500			0.001	0.03	20.1
5.47	0.0	0.661	0.313	0.974	1.500	1.500	0.0	0.0	0.002	0.12	20.3
6.47	0.0	0.653	0.305	0.958	1.500	1.500			0.043	1.39	20.4
7.47	0.0	0.655	0.305	0.960	1.500	1.500		0.0	0.228	9.19	21.4
8.47	0.0	0.686	0.264	0.910	1.500	1.500			0.513	30.91	23.2
9.47	0.0	0.668	0.239	0.906	1.500	1.500			0.721	67.55	24.7
10.47	0.0	0.657	0.216	0.874	1.500	1.500			0.994	118.51	26.7
11.47	0.0	0.667	0.224	0.890	1.500	1.500			1.032	179.22	28.4
12.47	0.0	0.667	0.206	0.873	1.500	1.500	0.0		0.697	231.70	28.9
13.47	0.0				1.500	1.500		0.0	0.644	272.02	29.3
14.47	0.0	0.662	0.197	0.859	1.500	1.500			0.804	315.17	29.6
15.47	0.0	0.664	0.193	0.857	1.500	1.500			0.667	359.55	28.4
16.47	0.0	0.656	0.198	0.854	1.500	1.500			0.431	392.91	27.7
17.47	0.0	0.641	0.197	0.837	1.500	1.500		0.0	0.118	409.95	26.1

RTI SMUG CHAMBER STUDY
USLPA CONTRACT NO. 68-02-2437

CHAMBER NO. 4
DAY 1, 9-18-77
RUN 29 1 COS

77 X SUNSHINE

TIME (EST)	OZONE (PPH)	NO (PPH)	NO ₂ (PPH)	NOX (PPH)	I-SUL (PPH)	COS (PPH)	I-P-3 (UG/H3)	CH-S (K-CN/CM3)	SH (L/MIN)	CU-SR (LANG)	TEMP CELSIUS
0.63	0.0	0.391 a/	0.100 a/	0.491 a/					0.0	0.0	21.4
1.63	0.0	0.370	0.110	0.480					0.0	0.0	20.8
2.63	0.0	0.372	0.118	0.491			0.0		0.001	0.06	20.2
3.63	0.0	0.366	0.114	0.485			0.0	0.0	0.004	0.27	19.7
4.63	0.0	0.368	0.124	0.487			0.0	0.0	0.045	2.06	20.2
5.63	0.0	0.366	0.124	0.487			0.0	0.0	0.238	12.06	20.4
6.63	0.0	0.366	0.102	0.460			0.0	0.0	0.238	16.91	20.4
7.63	0.0	0.370	0.092	0.462			0.0	0.0	0.567	18.77	22.0
8.63	0.0	0.365	0.091	0.456			0.0	0.0	0.783	80.96	25.1
9.63	0.0	0.362	0.090	0.452			0.0	0.220	1.005	136.33	27.2
10.63	0.0	0.358	0.089	0.449	1.500	1.500	0.0		0.921	193.45	28.1
11.63	0.0	0.355	0.089	0.445	1.500	1.500	0.0		1.193	259.00	29.3
12.63	0.0	0.357	0.093	0.450	1.500	1.500	0.0		1.078	326.23	29.6
13.63	0.0	0.361	0.089	0.450	1.500	1.500	0.0		0.701	376.06	29.1
14.63	0.0	0.355	0.092	0.448	1.500	1.500	0.0	0.0	0.668	417.47	29.1
15.63	0.0	0.337	0.094	0.431	1.500	1.500			0.398	447.34	29.1
16.63	0.0	0.336	0.088	0.425	1.500	1.500			0.108	460.26	26.9
17.63	0.0	0.328	0.094	0.422	1.500	1.500	0.0		0.005	462.85	25.1
18.63	0.0	0.325	0.095	0.420	1.500	1.500	0.0	0.0	0.0	462.96	23.8
19.63	0.0	0.313	0.084	0.397	1.500	1.500		0.0	0.0	462.96	21.9
20.63	0.0	0.304	0.091	0.395	1.500	1.500			0.0	462.96	21.7
21.63	0.0								0.0	462.96	21.4

a/ Interference corrected initial [NO], [NO₂], and [NO_x] are 0.381, 0.093, and 0.474 ppm.

DAY 2, 9-19-77

74 X SUNSHINE

TIME (EST)	OZONE (PPH)	NO (PPH)	NO ₂ (PPH)	NOX (PPH)	I-SUL (PPH)	COS (PPH)	I-P-3 (UG/H3)	CH-S (K-CN/CM3)	SH (L/MIN)	CU-SR (LANG)	TEMP CELSIUS
0.63	0.0	0.401	0.093	0.394	1.500	1.500			0.0	0.0	20.9
1.63	0.0	0.296	0.094	0.390	1.500	1.500			0.0	0.0	20.6
2.63	0.0	0.299	0.100	0.399	1.500	1.500			0.0	0.0	20.2
3.63	0.0	0.301	0.096	0.396	1.500	1.500			0.0	0.0	20.0
4.63	0.0	0.298	0.104	0.402	1.500	1.500			0.001	0.04	20.1
5.63	0.0	0.292	0.105	0.397	1.500	1.500	0.0		0.002	0.14	20.3
6.63	0.0	0.267	0.107	0.395	1.500	1.500		0.0	0.043	1.81	20.4
7.63	0.0	0.261	0.110	0.392	1.500	1.500			0.228	11.38	21.4
8.63	0.0	0.274	0.094	0.368	1.500	1.500		0.0	0.513	35.83	23.2
9.63	0.0	0.270	0.101	0.371	1.500	1.500			0.721	74.47	24.7
10.63	0.001	0.261	0.094	0.355	1.500	1.500			0.994	128.05	26.7
11.63	0.001	0.262	0.101	0.363	1.500	1.500			1.032	169.13	26.4
12.63	0.001	0.248	0.100	0.348	1.500	1.500	0.0		0.697	238.39	28.9
13.63	0.001	0.241	0.092	0.333	1.500	1.500		0.0	0.684	278.20	29.3
14.63	0.001	0.238	0.099	0.337	1.500	1.500			0.804	322.89	29.4
15.63	0.001	0.232	0.101	0.333	1.500	1.500			0.667	365.95	28.8
16.63	0.0	0.227	0.101	0.328	1.500	1.500			0.431	397.05	27.7
17.63	0.0	0.219	0.098	0.317	1.500	1.500		0.0	0.118	411.08	26.1

CHAMBER NO. 1									
DAY 1, 9-21-77									
RUN 30 : CS2									
64 X SUNSHINE									
TIME (EST)	OZONE (PPH)	NO (PPH)	NO2 (PPH)	HUX (PPH)	T-SUL (PPH)	CUS (PPH)	SU2 (PPH)	CS2 (PPH)	T-P-S (UG/M3)
0.13	0.0	0.004	0.001	0.005					
1.30	0.0	0.162	0.0	0.162					
2.30	0.0	0.162	0.037	0.199					
3.13	0.0	0.162	0.001	0.203					
4.13	0.0	0.160 a/	0.042 a/	0.202 a/					
5.13	0.0	0.161	0.043	0.204	1.500			1.500	
6.13	0.0	0.150	0.043	0.201	1.500			1.500	
7.13	0.0	0.146	0.053	0.201	1.500			1.500	
8.13	0.004	0.109	0.055	0.193	1.500			1.500	
9.13	0.014	0.083	0.103	0.186	1.500			1.500	
10.13	0.024	0.068	0.114	0.182	1.500	0.216		1.500	
11.13	0.032	0.056	0.116	0.174	1.500	0.269		1.500	
12.13	0.040	0.048	0.117	0.165	1.500	0.256		1.500	
13.13	0.044	0.038	0.113	0.151	1.500	0.409		1.500	
14.13	0.046	0.031	0.112	0.144	1.500	0.471		1.500	
15.13	0.052	0.030	0.110	0.139	1.500	0.519		1.500	
16.13	0.050	0.024	0.113	0.136	1.500	0.547		1.500	
17.13	0.042	0.016	0.115	0.131	1.500	0.538		1.500	
18.13	0.027	0.008	0.114	0.122	1.500	0.551		1.500	
19.13	0.015	0.004	0.108	0.111	1.500	0.538		1.500	
20.13	0.010	0.002	0.103	0.105	1.500	0.549		1.500	
21.13	0.006	0.002	0.099	0.101	1.500	0.542		1.500	
22.13	0.005	0.002	0.096	0.098	1.500	0.540		1.500	
23.13	0.003	0.001	0.095	0.096	1.500	0.535		1.500	
64 X SUNSHINE									
TIME (EST)	OZONE (PPH)	NO (PPH)	NO2 (PPH)	HUX (PPH)	T-SUL (PPH)	CUS (PPH)	SU2 (PPH)	CS2 (PPH)	T-P-S (UG/M3)
0.13	0.002	0.001	0.091	0.092	1.500	0.514	0.010	1.500	
1.13	0.001	0.000	0.090	0.090					
2.13	0.0	0.0	0.088	0.088					
3.13	0.0	0.000	0.086	0.086	1.500	0.520		1.500	
4.13	0.0	0.001	0.085	0.086	1.500	0.522		1.500	
5.13	0.0	0.001	0.084	0.085	1.500	0.522		1.500	
6.13	0.0	0.000	0.083	0.083	1.500	0.522		1.500	
7.13	0.025	0.008	0.072	0.080	1.500	0.535		1.500	
8.13	0.071	0.009	0.065	0.074	1.500	0.591		1.500	
9.13	0.101	0.009	0.056	0.065	1.500	0.707		1.500	
10.13	0.125	0.009	0.053	0.062	1.500	0.756		1.500	
11.13	0.166	0.007	0.048	0.055	1.500	0.836		1.500	
12.13	0.204	0.006	0.043	0.049	1.500	0.922		1.500	
13.13	0.244	0.005	0.037	0.042	1.500	0.981		1.500	
14.13	0.273	0.005	0.032	0.037	1.500	1.044		1.500	
15.13	0.295	0.006	0.027	0.033	1.500	1.127		1.500	
16.13	0.290	0.005	0.024	0.029	1.500	1.145		1.500	

a/ Consider this value to be the interference-corrected initial concentration.

DAY 2, 9-22-77									
60 X SUNSHINE									
TIME (EST)	OZONE (PPH)	NO (PPH)	NO2 (PPH)	HUX (PPH)	T-SUL (PPH)	CUS (PPH)	SU2 (PPH)	CS2 (PPH)	T-P-S (UG/M3)
0.13	0.002	0.001	0.091	0.092	1.500	0.514	0.010	1.500	
1.13	0.001	0.000	0.090	0.090					
2.13	0.0	0.0	0.088	0.088					
3.13	0.0	0.000	0.086	0.086	1.500	0.520		1.500	
4.13	0.0	0.001	0.085	0.086	1.500	0.522		1.500	
5.13	0.0	0.001	0.084	0.085	1.500	0.522		1.500	
6.13	0.0	0.000	0.083	0.083	1.500	0.522		1.500	
7.13	0.025	0.008	0.072	0.080	1.500	0.535		1.500	
8.13	0.071	0.009	0.065	0.074	1.500	0.591		1.500	
9.13	0.101	0.009	0.056	0.065	1.500	0.707		1.500	
10.13	0.125	0.009	0.053	0.062	1.500	0.756		1.500	
11.13	0.166	0.007	0.048	0.055	1.500	0.836		1.500	
12.13	0.204	0.006	0.043	0.049	1.500	0.922		1.500	
13.13	0.244	0.005	0.037	0.042	1.500	0.981		1.500	
14.13	0.273	0.005	0.032	0.037	1.500	1.044		1.500	
15.13	0.295	0.006	0.027	0.033	1.500	1.127		1.500	
16.13	0.290	0.005	0.024	0.029	1.500	1.145		1.500	
60 X SUNSHINE									
TIME (EST)	OZONE (PPH)	NO (PPH)	NO2 (PPH)	HUX (PPH)	T-SUL (PPH)	CUS (PPH)	SU2 (PPH)	CS2 (PPH)	T-P-S (UG/M3)
0.13	0.002	0.001	0.091	0.092	1.500	0.514	0.010	1.500	
1.13	0.001	0.000	0.090	0.090					
2.13	0.0	0.0	0.088	0.088					
3.13	0.0	0.000	0.086	0.086	1.500	0.520		1.500	
4.13	0.0	0.001	0.085	0.086	1.500	0.522		1.500	
5.13	0.0	0.001	0.084	0.085	1.500	0.522		1.500	
6.13	0.0	0.000	0.083	0.083	1.500	0.522		1.500	
7.13	0.025	0.008	0.072	0.080	1.500	0.535		1.500	
8.13	0.071	0.009	0.065	0.074	1.500	0.591		1.500	
9.13	0.101	0.009	0.056	0.065	1.500	0.707		1.500	
10.13	0.125	0.009	0.053	0.062	1.500	0.756		1.500	
11.13	0.166	0.007	0.048	0.055	1.500	0.836		1.500	
12.13	0.204	0.006	0.043	0.049	1.500	0.922		1.500	
13.13	0.244	0.005	0.037	0.042	1.500	0.981		1.500	
14.13	0.273	0.005	0.032	0.037	1.500	1.044		1.500	
15.13	0.295	0.006	0.027	0.033	1.500	1.127		1.500	
16.13	0.290	0.005	0.024	0.029	1.500	1.145		1.500	

RTI SMOG CHAMBER STUDY
USEPA CONTRACT NO. 68-02-2437

CHAMBER NO. 2
DAY 1, 9-21-77
RUN 30 : CS2

64 % SUNSHINE

TIME (EST)	OZONE (PPM)	NO (PPM)	NO2 (PPM)	NOX (PPM)	T-SUL (PPM)	COS (PPM)	SO2 (PPM)	CS2 (PPM)	T-P-S (UG/M3)	CN-S (K-CN/CM3)(L/MIN)	SR (L/MIN)	CU-SR (LANG) CELSIUS	TEMP CELSIUS
0.30	0.0	0.004	0.005	0.009	1.500	0.234	0.0	1.500	0.0	120.000	0.0	0.0	19.2
1.30	0.0	0.081	0.002	0.083	1.500	0.319	0.0	1.500	0.0	68.000	0.0	0.0	19.9
2.30	0.0	0.080	0.019	0.099	1.500	0.405	0.0	1.500	0.0	67.000	0.0	0.0	19.5
3.30	0.0	0.079	0.021	0.100	1.500	0.465	0.0	1.500	0.0	0.0	0.0	0.0	18.9
4.30	0.0	0.079	0.021	0.100	1.500	0.501	0.0	1.500	0.0	0.0	0.0	0.0	18.4
5.30	0.0	0.079	0.023	0.102	1.500	0.671	0.0	1.500	0.0	0.0	0.0	0.0	18.4
6.30	0.0	0.077	0.027	0.104	1.500	0.756	0.0	1.500	0.0	0.0	0.0	0.0	17.9
7.30	0.007	0.003	0.061	0.104	1.500	0.763	0.0	1.500	0.0	0.0	0.0	0.0	19.1
8.30	0.050	0.023	0.074	0.097	1.500	0.724	0.0	1.500	0.0	0.0	0.0	0.0	20.9
9.30	0.094	0.018	0.075	0.091	1.500	0.725	0.0	1.500	0.0	0.0	0.0	0.0	22.4
10.30	0.134	0.016	0.071	0.087	1.500	0.722	0.0	1.500	0.0	0.0	0.0	0.0	23.8
11.30	0.177	0.012	0.067	0.080	1.500	0.706	0.0	1.500	0.0	0.0	0.0	0.0	25.4
12.30	0.227	0.011	0.061	0.072	1.500	0.706	0.0	1.500	0.0	0.0	0.0	0.0	25.7
13.30	0.275	0.008	0.052	0.060	1.500	0.724	0.0	1.500	0.0	0.0	0.0	0.0	25.9
14.30	0.304	0.007	0.046	0.054	1.500	0.725	0.0	1.500	0.0	0.0	0.0	0.0	26.0
15.30	0.330	0.006	0.041	0.047	1.500	0.725	0.0	1.500	0.0	0.0	0.0	0.0	25.8
16.30	0.333	0.008	0.035	0.042	1.500	0.722	0.0	1.500	0.0	0.0	0.0	0.0	24.4
17.30	0.315	0.008	0.025	0.033	1.500	0.706	0.0	1.500	0.0	0.0	0.0	0.0	21.1
18.30	0.283	0.006	0.016	0.022	1.500	0.724	0.0	1.500	0.0	0.0	0.0	0.0	19.2
19.30	0.249	0.002	0.010	0.012	1.500	0.725	0.0	1.500	0.0	0.0	0.0	0.0	17.8
20.30	0.230	0.001	0.008	0.009	1.500	0.725	0.0	1.500	0.0	0.0	0.0	0.0	16.6
21.30	0.212	0.001	0.008	0.009	1.500	0.722	0.0	1.500	0.0	0.0	0.0	0.0	16.8
22.30	0.202	0.001	0.007	0.008	1.500	0.706	0.0	1.500	0.0	0.0	0.0	0.0	15.7
23.30	0.193	0.000	0.006	0.006	1.500	0.706	0.0	1.500	0.0	0.0	0.0	0.0	15.7

a/ Consider this value to be the interference-corrected initial concentration.

DAY 2, 9-22-77

66 % SUNSHINE

TIME (EST)	OZONE (PPM)	NO (PPM)	NO2 (PPM)	NOX (PPM)	T-SUL (PPM)	COS (PPM)	SO2 (PPM)	CS2 (PPM)	T-P-S (UG/M3)	CN-S (K-CN/CM3)(L/MIN)	SR (L/MIN)	CU-SR (LANG) CELSIUS	TEMP CELSIUS
0.30	0.186	0.0	0.007	0.007	1.500	0.693	0.0	1.500	0.0	0.0	0.0	0.0	15.1
1.30	0.179	0.0	0.007	0.007	1.500	0.703	0.0	1.500	0.0	0.0	0.0	0.0	13.9
2.30	0.172	0.0	0.006	0.006	1.500	0.703	0.0	1.500	0.0	0.0	0.0	0.0	12.9
3.30	0.166	0.0	0.006	0.006	1.500	0.703	0.0	1.500	0.0	0.0	0.0	0.0	12.3
4.30	0.163	0.0	0.006	0.006	1.500	0.699	0.0	1.500	0.0	0.0	0.0	0.0	12.1
5.30	0.157	0.0	0.006	0.006	1.500	0.697	0.0	1.500	0.0	0.0	0.0	0.0	11.8
6.30	0.152	0.0	0.005	0.005	1.500	0.682	0.0	1.500	0.0	0.0	0.0	0.0	12.1
7.30	0.145	0.0	0.006	0.006	1.500	0.706	0.0	1.500	0.0	0.0	0.0	0.0	14.6
8.30	0.142	0.002	0.009	0.011	1.500	0.717	0.010	1.500	0.0	0.0	0.0	0.0	17.6
9.30	0.151	0.004	0.010	0.014	1.500	0.717	0.010	1.500	0.0	0.0	0.0	0.0	19.4
10.30	0.178	0.006	0.011	0.019	1.500	0.839	0.067	1.500	0.0	0.0	0.0	0.0	23.7
11.30	0.224	0.007	0.012	0.019	1.500	0.908	0.091	1.500	0.0	0.0	0.0	0.0	28.2
12.30	0.263	0.006	0.013	0.019	1.500	0.952	0.105	1.500	0.0	0.0	0.0	0.0	28.7
13.30	0.294	0.005	0.015	0.020	1.500	0.999	0.101	1.500	0.0	0.0	0.0	0.0	25.0
14.30	0.319	0.005	0.015	0.020	1.500	0.999	0.101	1.500	0.0	0.0	0.0	0.0	24.9
15.30	0.333	0.006	0.015	0.021	1.500	1.061	0.139	1.500	0.0	0.0	0.0	0.0	24.5
16.30	0.327	0.006	0.015	0.021	1.500	1.071	0.139	1.500	0.0	0.0	0.0	0.0	24.5

RT1 SMUG CHAMBER STUDY
USEPA CONTRACT NO. 6A-02-2437

CHAMBER NO. 3
DAY 1, 9-21-77
RUN 30 1 CS2

64 % SUNSHINE

TIME (EST)	OZONE (PPM)	NO (PPM)	NO2 (PPM)	HUX (PPM)	I-SUL (PPM)	COS (PPM)	S02 (PPM)	CS2 (PPM)	I-P-S (UG/M3)	CN-S (K-CN/CM3) (L/MIN)	SR (L/MIN)	CU-SR (LANG)	TEMP (CELSIUS)
0.37	0.0	0.005	0.009	0.014							0.0	0.0	19.2
1.77	0.0	0.762 a/	0.193 a/	0.975 a/							0.0	0.0	19.9
3.47	0.0	0.760	0.216	0.976							0.0	0.0	18.9
4.47	0.0	0.751	0.227	0.978							0.0	0.0	18.4
5.47	0.0	0.739	0.238	0.977	1.500			1.500	0.0		0.045	0.0	17.9
6.47	0.0	0.726	0.249	0.975	1.500			1.500	0.0	90.000	0.255	9.89	19.1
7.47	0.0	0.710	0.251	0.961	1.500			1.500	0.0	91.000	0.515	32.52	20.9
8.47	0.0	0.688	0.249	0.937	1.500			1.500	0.0	66.000	0.759	70.30	22.4
9.47	0.0	0.669	0.245	0.914	1.500			1.500	0.0		0.993	122.44	23.8
10.47	0.0	0.674	0.232	0.906	1.500			1.500	0.0		1.102	185.10	24.8
11.47	0.0	0.659	0.238	0.897	1.500			1.500	0.0	41.000	1.079	250.57	25.4
12.47	0.0	0.642	0.224	0.867	1.500			1.500			0.962	312.01	25.7
13.47	0.0	0.621	0.218	0.839	1.500			1.500		28.000	0.733	363.27	25.9
14.47	0.0	0.601	0.215	0.815	1.500	0.223		1.500	0.0		0.626	404.23	26.0
15.47	0.0	0.604	0.208	0.812	1.500	0.257		1.500			0.349	433.98	25.8
16.47	0.0	0.612	0.212	0.824	1.500	0.239		1.500			0.097	447.81	24.4
17.47	0.0	0.519	0.211	0.789	1.500	0.234		1.500			0.001	450.93	21.1
18.47	0.0	0.571	0.222	0.793	1.500	0.223		1.500	0.0		0.0	450.96	19.2
19.47	0.0	0.565	0.221	0.786	1.500			1.500		1.300	0.0	450.96	17.8
20.47	0.0	0.556	0.220	0.776	1.500	0.265	0.010	1.500			0.0	450.96	16.8
21.47	0.0	0.546	0.230	0.776	1.500	0.271	0.010	1.500			0.0	450.96	15.7
22.47	0.0	0.538	0.231	0.769	1.500	0.246		1.500					
23.47	0.0	0.528	0.233	0.761	1.500			1.500					

a/ Consider this value to be the interference corrected initial concentration.

DAY 2, 9-22-77

66 % SUNSHINE

TIME (EST)	OZONE (PPM)	NO (PPM)	NO2 (PPM)	HUX (PPM)	I-SUL (PPM)	COS (PPM)	S02 (PPM)	CS2 (PPM)	I-P-S (UG/M3)	CN-S (K-CN/CM3) (L/MIN)	SR (L/MIN)	CU-SR (LANG)	TEMP (CELSIUS)
0.47	0.0	0.517	0.234	0.751	1.500	0.232	0.010	1.500			0.0	0.0	15.1
1.47	0.0	0.511	0.239	0.750	1.500	0.257		1.500			0.0	0.0	13.9
2.47	0.0	0.504	0.244	0.748	1.500	0.253		1.500			0.0	0.0	12.9
3.47	0.0	0.498	0.245	0.743	1.500	0.251		1.500			0.0	0.0	12.3
4.47	0.0	0.491	0.250	0.741	1.500	0.250		1.500	0.0		0.0	0.0	12.1
5.47	0.0	0.488	0.254	0.742	1.500	0.246		1.500			0.0	0.0	11.8
6.47	0.0	0.481	0.257	0.738	1.500	0.253		1.500			0.052	1.47	12.1
7.47	0.0	0.463	0.257	0.720	1.500	0.329	0.010	1.500		83.000	0.293	11.38	14.6
8.47	0.0	0.460	0.249	0.689	1.500	0.352	0.010	1.500			0.523	35.45	17.6
9.47	0.0	0.426	0.225	0.651	1.500	0.385	0.065	1.500			0.600	74.64	19.4
10.47	0.0	0.406	0.218	0.618	1.500	0.417	0.094	1.500			0.952	126.93	22.1
11.47	0.0	0.399	0.215	0.621	1.500	0.447	0.094	1.500			1.066	187.26	23.7
12.47	0.0	0.389	0.210	0.609	1.500	0.461	0.106	1.500			0.939	247.64	24.2
13.47	0.0	0.389	0.214	0.603	1.500	0.461	0.106	1.500	0.0	18.500	0.932	303.78	24.7
14.47	0.0	0.375	0.204	0.579	1.500	0.464	0.121	1.500			0.746	354.46	25.0
15.47	0.0	0.373	0.205	0.578	1.500	0.519	0.132	1.500			0.533	393.21	24.9
16.47	0.0	0.360	0.199	0.559	1.500	0.526		1.500	3.3	28.000	0.527	419.58	24.5

RTI SMUG CHAMBER STUDY
USEPA CONTRACT NO. 68-02-2437

CHAMBER NO. 4
DAY 1, 9-21-77
RUN 30 : CS2

64 % SUNSHINE

TIME (EST)	OZONE (PPH)	NO (PPH)	NO2 (PPH)	NOX (PPH)	I-SUL (PPH)	CO3 (PPH)	SO2 (PPH)	CS2 (PPH)	I-P-S (UG/M3)	CH-S (K-CN/CM3)(L/MIN)	SR	CU-SR (LANG)	TEMP CELSIUS
0.97	0.0	0.396	0.0	0.396							0.0	0.0	19.2
1.98	0.0	0.387	0.099	0.486							0.0	0.0	19.9
3.63	0.0	0.381	0.104	0.485							0.0	0.0	18.9
4.63	0.0	0.378	0.107	0.485							0.0	0.0	18.4
5.63	0.0	0.376	0.110	0.486	0.598			0.127	0.0	150.000	0.045	1.70	17.9
6.63	0.0	0.369	0.115	0.484	1.500			1.500	0.0	105.000	0.255	12.34	19.1
7.63	0.0	0.347	0.131	0.478	1.500			1.500	0.0	84.000	0.759	37.47	20.9
8.63	0.0	0.310	0.150	0.460	1.500			1.500	0.0		0.993	77.59	22.4
9.63	0.001	0.280	0.174	0.455	1.500			1.500			1.102	131.98	23.8
10.63	0.003	0.245	0.189	0.434	1.500	0.243		1.500	0.0	83.000	1.079	145.68	24.8
11.63	0.004	0.221	0.203	0.424	1.500	0.336		1.500			0.962	260.93	25.4
12.63	0.005	0.200	0.205	0.406	1.500	0.333		1.500		60.000	0.733	321.24	25.7
13.63	0.005	0.186	0.201	0.388	1.500	0.395		1.500			0.626	370.31	25.9
14.63	0.005	0.176	0.201	0.376	1.500	0.423		1.500			0.349	410.24	26.0
15.63	0.005	0.171	0.204	0.375	1.500	0.432	4.3	1.500	4.3		0.097	437.33	25.8
16.63	0.003	0.164	0.206	0.370	1.500	0.435		1.500			0.001	448.75	24.4
17.63	0.001	0.152	0.197	0.349	1.500	0.435		1.500			0.0	450.94	21.1
18.63	0.0	0.150	0.201	0.351	1.500	0.439		1.500			0.0	450.96	19.2
19.63	0.0	0.146	0.198	0.344					0.0		0.0	450.96	17.8
20.63	0.0	0.144	0.197	0.341	1.500	0.439	0.010	1.500		1.600	0.0	450.96	16.6
21.63	0.0	0.143	0.199	0.342	1.500	0.436	0.010	1.500			0.0	450.96	16.8
22.63	0.0	0.141	0.196	0.337	1.500	0.443	0.010	1.500			0.0	450.96	15.7
23.63	0.0	0.138	0.193	0.331	1.500	0.443	0.010	1.500			0.0	450.96	15.7

a/ Consider this value to be the interference-corrected initial concentration.

DAY 2, 9-22-77

60 % SUNSHINE

TIME (EST)	OZONE (PPH)	NO (PPH)	NO2 (PPH)	NOX (PPH)	I-SUL (PPH)	CUS (PPH)	SO2 (PPH)	CS2 (PPH)	I-P-S (UG/M3)	CH-S (K-CN/CM3)(L/MIN)	SR (L/MIN)	CU-SR (LANG)	TEMP CELSIUS
0.63	0.0	0.136	0.193	0.329	1.500	0.407	0.010	1.500			0.0	0.0	15.1
1.63	0.0	0.136	0.190	0.326	1.500	0.410		1.500			0.0	0.0	13.9
2.63	0.0	0.135	0.189	0.324	1.500	0.427		1.500			0.0	0.0	12.9
3.63	0.0	0.135	0.187	0.322	1.500	0.427		1.500			0.0	0.0	12.3
4.63	0.0	0.133	0.187	0.320	1.500	0.425		1.500			0.0	0.0	12.1
5.63	0.0	0.134	0.186	0.320	1.500	0.425		1.500	0.0		0.0	0.0	11.4
6.63	0.0	0.130	0.185	0.315	1.500	0.425		1.500			0.052	1.97	12.1
7.63	0.006	0.110	0.190	0.300	1.500	0.446		1.500		100.000	0.293	14.20	14.6
8.63	0.013	0.095	0.188	0.283	1.500	0.541	0.010	1.500			0.523	40.47	17.6
9.63	0.019	0.088	0.176	0.264	1.500	0.572	0.074	1.500			0.800	42.32	19.4
10.63	0.025	0.077	0.179	0.256	1.500	0.618	0.095	1.500			0.952	136.07	22.1
11.63	0.034	0.065	0.174	0.244	1.500	0.677	0.131	1.500			1.066	197.49	23.7
12.63	0.038	0.055	0.180	0.235	1.500	0.698	0.133	1.500			0.939	256.65	24.2
13.63	0.047	0.048	0.174	0.222	1.500	0.737	0.150	1.500	3.9	39.500	0.932	312.73	24.7
14.63	0.048	0.038	0.176	0.214	1.500	0.764	0.163	1.500			0.746	361.62	25.0
15.63	0.048	0.034	0.170	0.204	1.500	0.804	0.168	1.500			0.533	398.33	24.9
16.63	0.041	0.026	0.167	0.193	1.500	0.820		1.500	0.0	41.000	0.327	422.52	24.5

RTI SMUG CHAMBER STUDY
USEPA CONTRACT NO. 68-02-2437

CHAMBER NO. 1
DAY 1, 9-23-77
RUN 31 & H2S

51 X SUNSHINE

TIME (EST)	OZONE (PPM)	NO (PPM)	NO2 (PPM)	NOX (PPM)	T-SUL (PPM)	SO2 (PPM)	H2S (PPM)	T-P-S (UG/M3)	CN-5 (K-CN/CM3)	SR (L/MIN)	CU-SR (LANG) CELSIUS	TEMP CELSIUS
0.13	0.000	0.001	0.001	0.002	0.0	0.0	0.0			0.001	0.01	12.6
1.13	0.0	0.001	0.003	0.004	0.0	0.0	0.0			0.0	0.06	12.2
2.13					0.0	0.0	0.0			0.001	0.07	11.9
3.13										0.001	0.13	11.6
4.13								3.8	0.0	0.001	0.19	11.5
5.13	0.0	0.163	0.041	0.204	1.500	0.010	1.500			0.001	0.25	11.0
6.13	0.0	0.161 a/	0.041 a/	0.202 a/	1.500	0.010	1.500			0.046	0.66	11.9
7.13	0.0	0.170	0.026	0.198	1.500	0.010	1.500	0.0	63.000	0.254	5.04	14.0
8.12	0.0	0.191	0.007	0.198	1.500	0.010	1.500	0.0		0.525	22.08	18.4
9.10	0.000	0.202	0.001	0.203	1.500	0.010	1.500			0.730	54.18	21.7
10.10	0.0	0.209	0.001	0.210	1.500	0.010	1.500	0.0		0.898	98.99	23.5
11.08	0.000	0.210	0.003	0.214	1.500	0.081	1.500			0.831	151.47	24.3
12.13	0.001	0.218	0.000	0.218	1.500	0.114	1.500	0.0	120.000	1.048	205.51	25.6
13.13	0.001	0.221	0.001	0.221	1.500	0.125	1.500			0.848	266.83	25.7
14.13	0.001	0.223	0.002	0.225	1.500	0.142	1.500		105.000	0.822	317.51	26.0
15.13	0.001	0.227	0.0	0.227	1.500	0.169	1.500	0.0		0.596	365.07	26.3
16.13	0.0	0.230	0.0	0.230	1.500	0.162	1.500			0.322	398.69	25.9
17.13	0.0	0.229	0.0	0.229	1.500	0.143	1.500	0.0	125.000	0.063	416.15	24.3
18.12	0.0	0.230	0.002	0.232	1.500	0.116	1.500			0.001	420.49	21.4
19.12	0.0	0.227	0.004	0.230						0.0	420.54	19.1
20.10	0.0	0.223	0.004	0.227						0.0	420.54	17.8
21.10	0.0	0.221	0.005	0.225						0.0	420.54	17.2
22.10	0.001	0.217	0.006	0.223						0.0	420.54	16.7
23.08	0.001	0.214	0.006	0.219						0.0	420.54	15.8

a/ Consider this value to be the interference-corrected initial concentrations.

DAY 2, 9-24-77

36 X SUNSHINE

TIME (EST)	OZONE (PPM)	NO (PPM)	NO2 (PPM)	NOX (PPM)	T-SUL (PPM)	SO2 (PPM)	H2S (PPM)	T-P-S (UG/M3)	CN-5 (K-CN/CM3)	SR (L/MIN)	CU-SR (LANG) CELSIUS	TEMP CELSIUS
0.07	0.000	0.213	0.005	0.219	1.122		1.409			0.0	0.0	15.1
1.07	0.000	0.210	0.007	0.217	1.062		1.340			0.0	0.0	14.4
2.05	0.000	0.206	0.008	0.215	1.013		1.283			0.0	0.0	13.9
3.05	0.000	0.206	0.009	0.215	0.963		1.220			0.0	0.0	13.5
4.05	0.000	0.205	0.007	0.213	0.924		1.168			0.0	0.0	13.2
5.03	0.000	0.202	0.007	0.209	0.874		1.108	0.0	0.0	0.001	0.00	12.9
6.13	0.000	0.201	0.006	0.207	0.843		1.067	0.0	0.0	0.030	0.29	13.3
7.13	0.0	0.200	0.007	0.207	0.781		0.979			0.097	2.62	14.9
8.13	0.0	0.203	0.004	0.207	0.738		0.906			0.211	9.33	17.6
9.13	0.0	0.205	0.003	0.208	0.694		0.813			0.516	24.36	19.2
10.13	0.000	0.204	0.007	0.211	0.659		0.708			0.733	57.02	22.6
11.13	0.000	0.205	0.010	0.215	0.641		0.612			0.954	102.72	24.6
12.13	0.001	0.205	0.010	0.215	0.636		0.526	5.9	37.000	1.062	160.40	25.9
13.13	0.0	0.208	0.013	0.221	0.597		0.427			0.978	223.81	26.7
14.13	0.0	0.208	0.014	0.222						0.814	281.27	27.5
15.13	0.0	0.208	0.015	0.223	0.545	0.198	0.306			0.611	328.53	27.4
16.13	0.0	0.206	0.015	0.221	0.501	0.194	0.252			0.345	363.11	26.1
17.13	0.0	0.204	0.016	0.220	0.464		0.225	0.0		0.062	401.60	24.9
18.13	0.0	0.201	0.016	0.217	0.398					0.0	484.84	21.7
19.13									2.700	0.0	564.84	20.7

RTI SMOG CHAMBER STUDY
USEPA CONTRACT NO. 68-02-2417

CHAMBER NO. 2
DAY 1, 9-23-77
RUN 31 : H2S

51 % SUNSHINE

TIME (EST)	OZONE (PPH)	NO (PPH)	NO2 (PPH)	NOX (PPH)	T-SUL (PPH)	SO2 (PPH)	H2S (PPH)	T-P-S (UG/H3)	CH-S (K-CN/CM3)	SR (L/MIN)	CU-SR (LANG)	TEMP CELSIUS
0.30	0.000	0.001	0.003	0.004	0.0	0.0	0.0			0.001	0.02	12.6
1.30	0.0	0.003	0.003	0.006	0.0	0.0	0.0			0.0	0.06	12.2
2.30					0.0	0.0	0.0			0.001	0.08	11.9
3.30					1.500	0.0	1.500			0.001	0.14	11.6
4.30					1.500	0.010	1.500	4.6		0.001	0.20	11.5
5.30	0.0	0.082	0.022	0.104	1.500	0.010	1.500		0.0	0.001	0.26	11.8
6.30	0.0	0.082 a/	0.021 a/	0.103 a/	1.500	0.010	1.500			0.046	1.13	11.9
7.30	0.0	0.091	0.012	0.103	1.500	0.010	1.500	0.0		0.254	7.63	14.0
8.28	0.0	0.103	0.004	0.107	1.500	0.010	1.500	3.4	72.000	0.525	27.12	18.4
9.27	0.000	0.111	0.002	0.113	1.500	0.010	1.500			0.730	61.63	21.7
10.27	0.000	0.116	0.002	0.118	1.500	0.010	1.500			0.898	108.15	23.3
11.30	0.000	0.120	0.004	0.124	1.500	0.122	1.500	0.0		0.831	162.48	24.3
12.30	0.001	0.126	0.001	0.128	1.500	0.135	1.500	0.0	125.000	1.046	216.20	25.6
13.30	0.001	0.128	0.003	0.131	1.500	0.157	1.500			0.846	275.48	25.7
14.30	0.001	0.132	0.003	0.134	1.500	0.190	1.500		130.000	0.822	325.90	26.0
15.30	0.0	0.133	0.002	0.135	1.500	0.191	1.500	0.0		0.596	371.15	26.3
16.30	0.0	0.137	0.001	0.138	1.500	0.172	1.500		125.000	0.322	401.97	25.9
17.30	0.0	0.135	0.003	0.138	1.500	0.140	1.500	0.0		0.083	416.99	24.3
18.28	0.0	0.139	0.004	0.143	1.500					0.001	420.50	21.4
19.28	0.0	0.136	0.005	0.141	1.500					0.0	420.54	19.1
20.27	0.0	0.133	0.005	0.138	1.500					0.0	420.54	17.8
21.27	0.0	0.131	0.006	0.137	1.500					0.0	420.54	17.2
22.27	0.001	0.129	0.006	0.135	1.500					0.0	420.54	16.7
23.25	0.001	0.128	0.007	0.135	1.500					0.0	420.54	15.8

a/ Consider this value to be the interference-corrected initial concentration.

DAY 2, 9-24-77

36 % SUNSHINE

TIME (EST)	OZONE (PPH)	NO (PPH)	NO2 (PPH)	NOX (PPH)	T-SUL (PPH)	SO2 (PPH)	H2S (PPH)	T-P-S (UG/H3)	CH-S (K-CN/CM3)	SR (L/MIN)	CU-SR (LANG)	TEMP CELSIUS
0.23	0.000	0.127	0.006	0.133	0.910		1.158			0.0	0.0	15.1
1.23	0.000	0.127	0.006	0.133	0.844		1.078			0.0	0.0	14.4
2.22	0.000	0.125	0.007	0.132	0.793		1.016			0.0	0.0	13.9
3.22	0.000	0.125	0.006	0.131	0.736		0.947			0.0	0.0	13.5
4.22	0.000	0.124	0.006	0.130	0.687		0.883			0.0	0.0	13.2
5.20	0.000	0.122	0.005	0.127	0.641		0.825	0.0	0.0	0.001	0.01	12.9
6.30	0.000	0.121	0.005	0.126	0.593		0.770			0.030	0.60	13.3
7.30	0.0	0.122	0.004	0.126	0.545		0.694			0.097	3.61	14.9
8.30	0.0	0.125	0.004	0.129	0.505		0.618			0.211	11.40	17.6
9.30	0.0	0.126	0.006	0.132	0.471		0.536			0.516	29.63	19.2
10.30	0.000	0.122	0.013	0.135	0.435		0.435			0.733	64.49	22.6
11.30	0.001	0.120	0.020	0.140	0.409		0.329			0.954	112.45	24.6
12.30	0.002	0.111	0.023	0.134	0.398		0.228	11.7	47.000	1.062	171.64	25.9
13.30	0.002	0.106	0.025	0.132	0.370		0.228			0.978	233.84	26.7
14.30	0.002	0.099	0.030	0.129	0.362	0.194	0.125			0.814	289.57	27.3
15.30	0.002	0.092	0.029	0.121	0.344	0.187	0.085			0.611	334.76	27.4
16.30	0.001	0.085	0.032	0.117	0.317	0.181	0.063			0.345	366.63	26.1
17.30	0.001	0.081	0.034	0.115	0.292		0.062	8.1		0.0	382.24	24.9
18.30	0.0	0.078	0.033	0.112	0.228		0.0			0.0	384.84	21.7
19.30									2.300	0.0	384.84	20.7

HTI SHUG CHAMBER STUDY
USEPA CONTRACT NO. 68-02-2437

CHAMBER NO. 5
DAY 1, 9-23-77
RUN 31 & H2S

51 x SUNSHINE

TIME (EST)	OZONE (PPH)	NO (PPH)	NO2 (PPH)	NOX (PPH)	T-SUL (PPH)	SO2 (PPH)	H2S (PPH)	T-P-S (UG/M3)	CN-5 (K-CN/CM3)	SR (L/MIN)	CU-SR (LANG)	TEMP CELSIUS
0.47	0.000	0.004	0.004	0.009	0.0	0.0	0.0			0.001	0.03	12.6
1.47	0.0	0.005	0.005	0.010	0.0	0.0	0.0			0.0	0.06	12.2
2.47										0.001	0.09	11.9
3.47										0.001	0.15	11.6
4.47										0.001	0.21	11.5
5.47	0.0	0.753	0.212	0.965	1.500	0.0	1.500	0.0	0.0	0.001	0.27	11.8
6.47	0.0	0.741 a/	0.213 a/	0.954 a/	1.500	0.147	1.500			0.046	1.60	11.9
7.47	0.0	0.755	0.184	0.939	1.500	0.155	1.500			0.254	10.22	12.0
8.45	0.0	0.814	0.182	0.917	1.500	0.147	1.500	2.8	91.000	0.254	32.47	18.4
9.43	0.000	0.680	0.033	0.913	1.500	0.126	1.500	0.0		0.730	68.63	21.7
10.43	0.000	0.901	0.010	0.911	1.500	0.150	1.500	4.6		0.698	116.77	23.3
11.43	0.001	0.893	0.013	0.907	1.500	0.209	1.500			0.831	178.89	24.5
12.47	0.001	0.910	0.003	0.914	1.500	0.257	1.500	4.6	105.000	1.048	226.89	25.6
13.47	0.002	0.905	0.009	0.913	1.500	0.290	1.500			0.848	284.13	25.7
14.47	0.0	0.917	0.008	0.925	1.500	0.329	1.500	5.1	94.000	0.822	334.28	26.0
15.47	0.0	0.905	0.007	0.912	1.500	0.374	1.500			0.596	371.23	26.3
16.47	0.0	0.905	0.012	0.917	1.500	0.376	1.500			0.322	405.26	25.9
17.47	0.0	0.905	0.023	0.918	1.500	0.350	1.500	3.6	110.000	0.683	417.84	24.5
18.45	0.0	0.903	0.029	0.932	1.500	0.292	1.500			0.001	420.51	21.4
19.45	0.0	0.874	0.047	0.921	1.500					0.0	420.54	19.1
20.43	0.0	0.854	0.062	0.916	1.500					0.0	420.54	17.8
21.43	0.0	0.832	0.071	0.903	1.500					0.0	420.54	17.2
22.43	0.001	0.818	0.085	0.903	1.500					0.0	420.54	16.7
23.42	0.000	0.802	0.089	0.891	1.500					0.0	420.54	15.8

a/ Data are insufficient to permit correction for interference.

DAY 2, 9-24-77

36 x SUNSHINE

TIME (EST)	OZONE (PPH)	NO (PPH)	NO2 (PPH)	NOX (PPH)	T-SUL (PPH)	SO2 (PPH)	H2S (PPH)	T-P-S (UG/M3)	CN-5 (K-CN/CM3)	SR (L/MIN)	CU-SR (LANG)	TEMP CELSIUS
0.40	0.000	0.790	0.101	0.891	0.848		0.945			0.0	0.0	15.1
1.40	0.000	0.774	0.109	0.883	0.793		0.878			0.0	0.0	14.4
2.38	0.000	0.759	0.121	0.879	0.736		0.816			0.0	0.0	13.9
3.38	0.000	0.750	0.124	0.874	0.687		0.756			0.0	0.0	13.5
4.38	0.000	0.740	0.131	0.870	0.641		0.701			0.0	0.0	13.2
5.37	0.000	0.724	0.135	0.859	0.597		0.650	0.0		0.001	0.02	12.9
6.47	0.000	0.708	0.146	0.853	0.552		0.595			0.030	0.91	13.3
7.47	0.0	0.703	0.136	0.838	0.529		0.543			0.097	4.60	14.9
8.47	0.0	0.698	0.130	0.828	0.487		0.483			0.211	13.63	17.6
9.47	0.000	0.701	0.106	0.808	0.471		0.404			0.516	34.89	19.2
10.47	0.000	0.694	0.092	0.786	0.441		0.294			0.733	71.97	22.6
11.47	0.000	0.682	0.091	0.773	0.398			14.8	21.000	0.954	122.18	24.6
12.47	0.0	0.671	0.089	0.761	0.418					1.062	182.47	25.9
13.47	0.0	0.655	0.091	0.747	0.418					0.978	243.82	26.7
14.47	0.0	0.650	0.086	0.736	0.433					0.814	292.87	27.3
15.47	0.0	0.631	0.082	0.723	0.404					0.611	340.94	27.4
16.47	0.0	0.620	0.093	0.713	0.366					0.345	370.15	26.1
17.47	0.0	0.617	0.098	0.716	0.354					0.062	382.87	24.9
18.47	0.0	0.604	0.100	0.709	0.287			3.2		0.0	384.84	21.7
19.47									2.300	0.0	384.84	20.7

RTI SHUG CHAMBER STUDY
USEPA CONTRACT NO. 68-02-2437

CHAMBER NO. 4
DAY 1, 9-23-77
RUN 31 8 H2S

51 X SUNSHINE

TIME (EST)	OZONE (PPH)	NO (PPH)	NO2 (PPH)	HUX (PPH)	I-SUL (PPH)	SU2 (PPH)	H2S (PPH)	I-P-S (UG/M3)	CN-5 (K-CN/CM3)	SR (L/MIN)	CU-SR (LANG)	TEMP CELSIUS
0.63	0.001	0.002	0.004	0.005	0.0	0.0	0.0			0.001	0.04	12.6
1.63	0.0	0.003	0.003	0.006	0.0	0.0	0.0			0.0	0.06	12.2
2.63										0.001	0.10	11.9
3.63										0.001	0.16	11.6
4.63	0.0	0.189	0.103	0.492	1.500	0.0	1.500	2.9	0.0	0.001	0.22	11.5
5.63	0.0	0.305 a/	0.104 a/	0.489 a/	1.500	0.010	1.500			0.001	0.28	11.8
6.63	0.0	0.405	0.073	0.478	1.500	0.010	1.500	2.8		0.046	2.04	11.9
7.63	0.0	0.450	0.024	0.474	1.500	0.010	1.500	0.0	90.000	0.254	12.66	14.0
8.62	0.0	0.473	0.005	0.478	1.500	0.068	1.500	0.0		0.525	37.83	16.4
9.60	0.0	0.478	0.003	0.481	1.500	0.084	1.500	0.0		0.730	76.08	21.7
10.60	0.000	0.480	0.007	0.484	1.500	0.171	1.500	0.0		0.890	125.93	23.3
11.60	0.001	0.486	0.004	0.491	1.500	0.189	1.500	0.0	95.000	0.831	187.37	24.3
12.63	0.001	0.488	0.004	0.491	1.500	0.198	1.500			1.048	236.95	25.6
13.63	0.001	0.488	0.004	0.491	1.500	0.239	1.500		105.000	0.846	292.27	25.7
14.63	0.002	0.493	0.004	0.497	1.500	0.262	1.500	0.0		0.822	342.17	26.0
15.63	0.0	0.492	0.001	0.493	1.500	0.249	1.500	0.0		0.596	362.95	26.3
16.63	0.0	0.491	0.001	0.492	1.500	0.202	1.500	0.0	98.000	0.322	408.35	25.9
17.63	0.0	0.488	0.005	0.493	1.500		1.500			0.083	418.64	24.3
18.62	0.0	0.486	0.008	0.494	1.500		1.500			0.001	420.52	21.4
19.62	0.0	0.475	0.014	0.489	1.375					0.0	420.54	19.1
20.66	0.0	0.466	0.020	0.486						0.0	420.54	17.0
21.60	0.0	0.458	0.023	0.481						0.0	420.54	17.2
22.60	0.001	0.453	0.025	0.478						0.0	420.54	16.7
23.56	0.000	0.447	0.031	0.474						0.0	420.54	15.8

a/ Data are insufficient to permit correction for interference.

DAY 2, 9-24-77

36 X SUNSHINE

TIME (EST)	OZONE (PPH)	NO (PPH)	NO2 (PPH)	HUX (PPH)	I-SUL (PPH)	SU2 (PPH)	H2S (PPH)	I-P-S (UG/M3)	CN-5 (K-CN/CM3)	SR (L/MIN)	CU-SR (LANG)	TEMP CELSIUS
0.57	0.000	0.442	0.033	0.474	0.411		0.967			0.0	0.0	15.1
1.57	0.000	0.435	0.035	0.471	0.763		0.917			0.0	0.0	14.4
2.55	0.000	0.431	0.036	0.467	0.710		0.871			0.0	0.0	13.9
3.55	0.000	0.427	0.038	0.465	0.669		0.818			0.0	0.0	13.5
4.55	0.000	0.422	0.039	0.461	0.628		0.768			0.0	0.0	13.2
5.55	0.000	0.418	0.042	0.456	0.589		0.720	0.0	0.0	0.001	0.03	12.9
6.63	0.0	0.409	0.044	0.453	0.543		0.664			0.030	1.19	13.3
7.63	0.0	0.408	0.039	0.448	0.517		0.607			0.097	5.53	14.9
8.63	0.0	0.408	0.036	0.443	0.481		0.536			0.211	15.66	17.6
9.63	0.000	0.406	0.035	0.441	0.450		0.448			0.516	34.84	19.2
10.63	0.000	0.398	0.042	0.440	0.423		0.340			0.733	74.01	22.6
11.63	0.0	0.387	0.048	0.435	0.411		0.251	10.5	32.000	0.954	131.34	24.6
12.63	0.0	0.379	0.050	0.429	0.411					1.062	192.66	25.9
13.63	0.0	0.370	0.050	0.420	0.393					0.978	253.21	26.7
14.63	0.0	0.360	0.053	0.414	0.396	0.200	0.114			0.614	305.69	27.3
15.63	0.0	0.348	0.055	0.404	0.362	0.191	0.089			0.611	346.86	27.4
16.63	0.0	0.345	0.055	0.400	0.343	0.188	0.073			0.345	373.46	26.1
17.63	0.0	0.336	0.066	0.402	0.301			0.0		0.062	383.46	24.9
18.63	0.0	0.332	0.055	0.387	0.228					0.0	384.84	21.7
19.63									2.000	0.0	384.84	20.7

HTI 3006 CHAMBER STUDY
USEPA CONTRACT NO. 68-02-2437

CHAMBER 010, 1
DAY 1, 9-20-77
RUN 3c 1 CH3-3-CH3

89 & SIMS/HTL

TIME (EST)	0200L (PPM)	100 (PPM)	1002 (PPM)	1003 (PPM)	1-SHL (PPM)	SU2 (PPM)	I-P-S (UG/M3)	CN-5 (K-CH/CH3)	SR (L/MIN)	CU-SR (LANG)	TEMP CELSIUS
0.13	0.0	0.006	0.005	0.008	1.500	0.0	0.0		0.0	0.0	19.3
1.13	0.0	0.013	0.0	0.015	1.500	0.0			0.0	0.0	18.3
2.13	0.0	0.012	0.0	0.012	1.500	0.0			0.0	0.0	16.6
3.77	0.0	0.159	0.0	0.159	1.500				0.0	0.0	15.5
5.30	0.0	0.159	0.0	0.198	1.500			0.0	0.0	0.0	14.1
6.13	0.0	0.156	0.058	0.194	1.500		0.0		0.037	0.29	14.2
7.13	0.001	0.129	0.057	0.166	1.500				0.259	0.24	16.6
8.13	0.076	0.015	0.130	0.151	1.591		151.3	9.100	0.506	27.02	20.9
9.13	0.355	0.006	0.037	0.093	1.003		90.3	9.100	0.792	56.70	23.2
10.13	0.002	0.005	0.012	0.017	0.662		123.0		0.908	105.75	23.8
11.13	0.301	0.005	0.008	0.013	0.698		90.0	2.900	1.008	165.88	24.6
12.13	0.350	0.005	0.006	0.011	0.669				1.130	232.01	24.8
13.13	0.323	0.005	0.008	0.013	0.621				0.864	297.74	24.8
14.13	0.293	0.005	0.009	0.014	0.485			1.000	0.516	306.06	24.3
15.13	0.267	0.004	0.009	0.015	0.466		29.7		0.374	376.72	23.9
16.47	0.229	0.005	0.007	0.012	0.476				0.237	402.92	23.2
17.47	0.195	0.007	0.007	0.014	0.476				0.051	411.90	21.9
18.63	0.175	0.006	0.004	0.010	0.457				0.0	413.52	20.2
19.63	0.126	0.006	0.004	0.010	0.439				0.0	413.52	19.2
20.13	0.115	0.006	0.008	0.010	0.421		0.0		0.0	413.52	18.2
21.13	0.093	0.004	0.004	0.008	0.412				0.0	413.52	17.1
22.13	0.075	0.002	0.004	0.006	0.408			0.250	0.0	413.52	16.1
23.47	0.056	0.0	0.003	0.003	0.390				0.0	413.52	13.6

a/ Interference-corrected Initial [NO], [NO₂], and [NO_x] are 0.140, 0.039, and 0.188 ppm.

DAY 2, 9-20-77

13 & SIMS/HTL

TIME (EST)	0200L (PPM)	100 (PPM)	1002 (PPM)	1003 (PPM)	I-SHL (PPM)	SU2 (PPM)	I-P-S (UG/M3)	CN-5 (K-CH/CH3)	SR (L/MIN)	CU-SR (LANG)	TEMP CELSIUS
0.97	0.040	0.0	0.002	0.002	0.301				0.0	0.0	11.3
1.97	0.032	0.0	0.002	0.002	0.374				0.001	0.06	10.2
2.97	0.024	0.0	0.002	0.002	0.368				0.001	0.12	9.6
3.97	0.018	0.000	0.003	0.003	0.361				0.001	0.18	6.7
4.97	0.019	0.000	0.003	0.003	0.359				0.001	0.24	6.1
6.13	0.011	0.001	0.003	0.004	0.350		0.0	0.225	0.037	0.59	7.7
7.13	0.008	0.003	0.003	0.006	0.336				0.311	0.95	10.8
8.13	0.015	0.006	0.003	0.007	0.319				0.257	24.74	16.6
9.13	0.054	0.006	0.003	0.007	0.315				0.735	58.33	19.0
10.13	0.067	0.005	0.000	0.011	0.301				0.820	99.10	20.6
11.13	0.109	0.004	0.000	0.010	0.290				0.868	108.07	21.3
12.13	0.107	0.004	0.007	0.011	0.275			2.700	0.801	200.54	22.0
13.13	0.112	0.005	0.007	0.012	0.275				0.808	250.74	22.2
14.03	0.109	0.009	0.006	0.017	0.271				0.556	313.98	22.3
15.13	0.104	0.010	0.008	0.016	0.261				0.400	329.71	22.0
16.13	0.177	0.010	0.008	0.019	0.184				0.189	354.15	21.2
17.13	0.177	0.011	0.007	0.019	0.159				0.000	364.33	19.8
18.13	0.140	0.011	0.006	0.017	0.139			1.000	0.0	366.42	17.7

N11 540H, CHANNEL STUDY
 USEFUL CHANNEL 1 NO. 00-02-2037

CHANNEL 100, 2
 DAY 1, 9-20-77
 000, 30 1 CH3-5-CH3

TIME (EST)	02000 (PPM)	100 (PPM)	1002 (PPM)	100X (PPM)	1-50L (PPM)	50L2 (PPM)	1-P-S (100/113)	CN-5 (K-CN/CH3)	SM (L/MIN)	(U-SM) (L/MIN)	TEMP (CELSIUS)
0.30	0.0	0.005	0.004	0.009					0.0	0.0	19.3
1.30	0.0	0.005	0.004	0.009					0.0	0.0	18.3
2.30	0.0	0.011	0.0	0.011	1.500	0.0			0.0	0.0	16.6
3.30	0.0	0.014	0.0	0.014	1.500				0.0	0.0	15.5
4.30	0.0	0.019	0.019	0.019	1.500			0.0	0.0	0.0	14.7
5.30	0.0	0.019	0.019	0.019	1.500				0.0	0.0	14.1
6.30	0.0	0.015	0.015	0.015	1.500		0.0		0.037	0.67	14.2
7.30	0.004	0.006	0.004	0.007	1.500				0.259	6.88	16.6
8.30	0.131	0.007	0.007	0.006	1.423		117.8	10.000	0.546	27.59	20.9
9.30	0.262	0.007	0.007	0.006	1.203		92.0	11.000	0.792	64.78	23.2
10.30	0.311	0.007	0.007	0.006	1.110		76.2		0.908	115.62	23.8
11.30	0.318	0.006	0.006	0.007	1.032				1.098	177.08	24.6
12.30	0.315	0.006	0.006	0.006	0.940		61.0	2.400	1.130	263.54	24.8
13.30	0.304	0.006	0.006	0.006	0.780			1.100	0.864	306.55	24.8
14.30	0.283	0.005	0.005	0.005	0.713		16.5		0.516	352.13	24.3
15.30	0.269	0.004	0.004	0.004	0.679				0.378	380.53	23.9
16.30	0.255	0.005	0.005	0.005	0.616				0.237	405.20	23.2
17.30	0.206	0.009	0.009	0.009	0.678				0.051	412.39	21.9
18.30	0.166	0.009	0.009	0.009	0.678				0.0	413.52	20.2
19.30	0.140	0.008	0.008	0.008	0.653				0.0	413.52	19.2
20.30	0.127	0.009	0.009	0.009	0.601		0.0		0.0	413.52	18.2
21.30	0.106	0.005	0.005	0.005	0.630				0.0	413.52	17.1
22.30	0.069	0.002	0.002	0.002	0.613			0.210	0.0	413.52	16.1
23.30	0.000	0.001	0.002	0.004	0.588				0.0	413.52	13.6

g/ Interference-corrected Initial [NO], [NO₂], and NO_x are 0.065, 0.020, and 0.085 ppm.

DAY 2, 9-20-77

1.5 X SUMSHEET

TIME (EST)	02000 (PPM)	100 (PPM)	1002 (PPM)	100X (PPM)	1-50L (PPM)	50L2 (PPM)	1-P-S (100/113)	CN-5 (K-CN/CH3)	SM (L/MIN)	(U-SM) (L/MIN)	TEMP (CELSIUS)
1.30	0.049	0.001	0.001	0.003	0.511				0.001	0.01	10.2
2.30	0.039	0.002	0.002	0.003	0.566				0.001	0.07	9.6
3.30	0.031	0.001	0.001	0.003	0.559				0.001	0.13	8.7
4.30	0.029	0.002	0.001	0.003	0.509				0.001	0.19	8.1
5.30	0.019	0.003	0.001	0.004	0.505			0.0	0.001	0.25	7.6
6.30	0.019	0.002	0.002	0.003	0.536		0.0		0.037	0.97	7.7
7.30	0.013	0.009	0.002	0.003	0.529				0.311	8.12	10.8
8.30	0.011	0.007	0.003	0.003	0.519		0.0		0.057	24.01	16.6
9.30	0.003	0.006	0.004	0.004	0.500				0.755	61.83	19.8
10.30	0.004	0.005	0.005	0.010	0.478				0.820	107.86	20.6
11.30	0.034	0.005	0.005	0.011	0.478				0.828	157.52	21.3
12.30	0.170	0.005	0.005	0.011	0.478		0.0	2.600	0.881	209.12	22.0
13.30	0.009	0.009	0.009	0.016	0.446				0.888	258.98	22.2
14.30	0.212	0.009	0.009	0.016	0.379				0.550	319.61	22.3
15.30	0.231	0.010	0.010	0.016	0.379				0.840	334.20	22.0
16.30	0.179	0.010	0.010	0.016	0.333				0.189	356.08	21.2
17.30	0.170	0.010	0.010	0.016	0.276		0.0		0.000	364.78	19.8
18.30	0.100	0.010	0.010	0.016	0.276			2.000	0.0	366.82	17.7

NO. 3486, 1 MAR 1964 W. STUY
1514-A CHINA (1) 11. 68-02-2037

[illegible]

/ Interference-corrected initial $[N]$, $[NO_2]$, and $[NO_x]$ are 0.777, 0.208, and 0.985 ppm.

DAY 2, 9-29-77											
TIME (EST)	WZHH (MM)	MO (MM)	YR (YY)	13 & SUMMIT			1-P-S (106.7/MS)	CR-S (K-CN/MS)	SR (1./MIN)	CU-SR (LAUG)	TEMP CEL SIUS
				I-SOL (PPH)	SOL (PPH)	SOL (PPH)					
1.50	0.270	0.0	0.019	0.019	0.019			0.001	0.02	10.2	
2.50	0.259	0.0	0.019	0.019	0.019			0.001	0.08	9.6	
3.50	0.247	0.0	0.019	0.019	0.019			0.001	0.14	8.7	
4.50	0.239	0.0	0.019	0.019	0.019			0.001	0.20	8.1	
5.50	0.231	0.0	0.019	0.019	0.019			0.001	0.26	7.6	
6.47	0.220	0.0	0.019	0.019	0.019			0.057	1.50	7.7	
7.47	0.209	0.001	0.019	0.019	0.019		0.0	0.511	11.29	10.8	
8.47	0.196	0.002	0.021	0.023	0.023			0.457	34.07	16.6	
9.47	0.187	0.003	0.022	0.022	0.022			0.735	69.55	19.4	
10.47	0.179	0.002	0.024	0.026	0.026			0.020	115.82	20.6	
11.47	0.2242	0.003	0.025	0.026	0.026			0.068	166.58	21.5	
12.47	0.209	0.003	0.030	0.030	0.030		0.0	0.041	217.70	22.0	
13.47	0.2091	0.005	0.031	0.031	0.031			0.008	267.25	22.2	
14.47	0.206	0.007	0.027	0.027	0.027			0.526	525.28	22.5	
15.47	0.206	0.009	0.026	0.026	0.026			0.440	550.69	22.0	
16.47	0.206	0.009	0.025	0.025	0.025			0.189	350.01	21.2	
17.47	0.206	0.009	0.025	0.025	0.025		0.0	0.000	505.15	19.8	
18.47	0.206	0.009	0.025	0.025	0.025		0.0	0.0	506.92	17.7	

RTI SHOW CHAMBER STUDY
USEPA CONTRACT NO. 66-02-2437

CHAMBER NO. 4
DAY 1, 9-28-77
RHH 5' x 6' x 5-1/2' 6.4 x 504SHHDL

TIME (EST)	OZONE (PPM)	HO (PPM)	HO ₂ (PPM)	NO _x (PPM)	I-SUL (PPM)	S02 (PPM)	I-P-S (UG/H3)	CN-5 (K-CN/CH3)	SR (L/MIN)	CU-SR (LANG) CELSIUS	TEMP CELSIUS
0.63	0.0	0.005	0.005	0.008					0.0	0.0	19.3
1.63	0.0	0.006	0.006	0.010					0.0	0.0	18.3
3.63	0.0	0.012	0.0	0.012	1.500	0.0			0.0	0.0	16.6
5.63	0.0	0.009	0.0	0.009	1.500	0.0			0.0	0.0	15.5
7.63	0.0	0.000	0.111 a/	0.511 a/	1.500			0.0	0.0	0.0	14.7
9.63	0.0	0.000	0.112	0.505	1.500				0.0	0.0	14.1
11.63	0.0	0.000	0.117	0.497	1.500		4.5		0.037	1.40	14.2
13.63	0.001	0.001	0.250	0.274	1.500				0.259	12.01	16.6
15.63	0.001	0.001	0.263	0.269	1.500	0.010	0.3	20.000	0.546	30.40	20.9
17.63	0.001	0.001	0.265	0.269	1.500	0.108	0.1	30.000	0.792	80.46	23.2
19.63	0.001	0.001	0.265	0.265	1.500	0.097	0.4	3.500	1.110	265.91	24.8
21.63	0.001	0.001	0.265	0.265	1.500	0.078			0.868	323.66	24.8
23.63	0.001	0.001	0.265	0.265	1.500	0.061			0.516	362.34	24.3
25.63	0.001	0.001	0.265	0.265	1.500	0.010	52.6		0.378	307.94	23.9
27.63	0.001	0.001	0.265	0.265	1.500	0.010			0.237	410.03	23.2
29.63	0.001	0.001	0.265	0.265	1.500	0.010			0.051	413.43	21.9
31.63	0.001	0.001	0.265	0.265	1.500	0.010			0.0	413.52	19.2
33.63	0.001	0.001	0.265	0.265	1.500	0.010			0.0	413.52	18.2
35.63	0.001	0.001	0.265	0.265	1.500	0.010			0.0	413.52	17.1
37.63	0.001	0.001	0.265	0.265	1.500	0.010			0.0	413.52	16.1
39.63	0.001	0.001	0.265	0.265	1.500	0.010			0.0	413.52	13.6

a/ Interference-corrected initial [NO], [NO₂], and [NO_x] are 0.380, 0.111, and 0.500 ppm.

DAY 2, 9-29-77

1.5 x 504SHHDL

TIME (EST)	OZONE (PPM)	HO (PPM)	HO ₂ (PPM)	NO _x (PPM)	I-SUL (PPM)	S02 (PPM)	I-P-S (UG/H3)	CN-5 (K-CN/CH3)	SR (L/MIN)	CU-SR (LANG) CELSIUS	TEMP CELSIUS
1.47	0.144	0.0	0.008	0.008					0.001	0.03	10.2
3.47	0.150	0.0	0.008	0.008					0.001	0.04	9.6
5.47	0.117	0.0	0.009	0.009					0.001	0.15	8.7
7.47	0.106	0.0	0.009	0.009					0.001	0.21	8.1
9.47	0.085	0.0	0.009	0.009				0.225	0.037	1.70	7.7
11.47	0.077	0.002	0.010	0.012			0.0		0.311	14.28	10.8
13.47	0.080	0.003	0.010	0.013					0.457	38.45	16.6
15.47	0.104	0.003	0.012	0.015					0.735	76.38	19.8
17.47	0.145	0.002	0.013	0.016					0.820	123.70	20.6
19.47	0.190	0.003	0.013	0.018					0.868	174.71	21.3
21.47	0.254	0.003	0.013	0.018					0.808	274.98	22.2
23.47	0.265	0.003	0.013	0.023	0.010	0.010			0.440	342.91	22.0
25.47	0.252	0.007	0.014	0.023	0.010	0.010			0.189	359.62	21.2
27.47	0.252	0.007	0.013	0.022	0.010	0.010			0.040	365.53	19.8
29.47	0.252	0.007	0.013	0.022	0.010	0.010	0.0	1.700	0.0	366.42	17.7

PIE SMUG. CHARACTER STUDY
US EPA CONTRACT NO. 68-02-2437

CHARACTER NO. 1
DAY 1, 10-3-77
RUN 33 1 12405-5-11

TIME (:51)	O2/100 (PPH)	HI (PPH)	LO2 (PPH)	LOX (PPH)	1-SUL (PPH)	SO2 (PPH)	1-P-S (UG/M3)	CH-S (K-CH/CH3)	SR (L/MIN)	CU-SH (LANG)	TEMP CELSIUS
0.63	0.0	0.003	0.005	0.006	0.0	0.0	0.0	1.000	0.0	0.0	0.0
1.00	0.0	0.023	0.0	0.023	1.500	0.0	0.0	0.0	0.0	0.0	0.0
2.63	0.0	0.023	0.0	0.023	1.500	0.0	0.0	0.0	0.0	0.0	0.0
3.63	0.0	0.163	0.0	0.163	1.500	0.0	0.0	0.0	0.0	0.0	0.0
5.22	0.0	0.101	0.032	0.193	1.500	0.0	0.0	0.0	0.0	0.0	0.0
6.50	0.0	0.150	0.021	0.179	1.500	0.0	0.0	0.0	0.0	0.0	0.0
7.13	0.0	0.111	0.066	0.178	1.500	0.0	0.0	0.0	0.0	0.0	0.0
8.13	0.042	0.023	0.008	0.110	1.181	0.221	41.4	41.000	0.570	23.53	14.6
9.13	0.076	0.018	0.072	0.090	0.935	0.280	68.4	37.000	0.558	58.05	14.7
10.63	0.070	0.010	0.067	0.081	0.765	0.217	98.2	0.0	0.864	108.72	14.7
11.13	0.063	0.015	0.060	0.081	0.708	0.178	0.0	0.0	0.730	120.71	15.0
12.13	0.062	0.011	0.065	0.079	0.637	0.157	93.0	0.0	1.088	167.31	16.2
13.00	0.130	0.011	0.068	0.079	0.551	0.117	27.4	10.000	1.098	276.80	17.1
14.13	0.137	0.010	0.066	0.076	0.526	0.117	0.0	0.0	0.718	295.58	17.3
15.63	0.142	0.009	0.064	0.074	0.415	0.100	0.0	0.0	0.650	352.63	17.4
16.13	0.149	0.008	0.061	0.069	0.357	0.010	0.0	0.0	0.313	374.50	16.7
17.13	0.122	0.007	0.063	0.070	0.280	0.010	0.0	0.0	0.071	391.39	15.6
18.47	0.095	0.008	0.062	0.067	0.252	0.010	0.0	0.0	0.071	393.52	15.6
19.30	0.064	0.007	0.060	0.067	0.252	0.010	0.0	0.0	0.0	395.10	12.3
19.97	0.075	0.008	0.059	0.067	0.252	0.010	0.0	0.0	0.0	395.10	12.6
21.13	0.061	0.007	0.057	0.064	0.252	0.010	0.0	0.0	0.0	395.10	12.6
22.30	0.050	0.007	0.056	0.063	0.252	0.010	0.0	0.0	0.0	395.10	7.1
23.00	0.040	0.005	0.050	0.059	0.252	0.010	0.0	0.0	0.0	395.10	5.9

a/ Interference-corrected initial [NO], [NO₂], and [NO_x] are 0.137, 0.048, and 0.185 ppm.

PAY 2, 10-4-77

TIME (:51)	O2/100 (PPH)	HI (PPH)	LO2 (PPH)	LOX (PPH)	1-SUL (PPH)	SO2 (PPH)	1-P-S (UG/M3)	CH-S (K-CH/CH3)	SR (L/MIN)	CU-SH (LANG)	TEMP CELSIUS
0.00	0.034	0.006	0.055	0.059	0.0	0.0	0.0	0.0	0.001	0.05	5.2
1.00	0.023	0.006	0.052	0.058	0.0	0.0	0.0	0.0	0.001	0.11	4.6
3.17	0.022	0.006	0.051	0.057	0.0	0.0	0.0	0.0	0.0	0.18	3.6
6.63	0.016	0.005	0.049	0.056	0.0	0.0	0.0	0.0	0.0	0.18	3.1
9.63	0.015	0.006	0.049	0.055	0.0	0.0	0.0	0.0	0.0	0.18	2.8
1.13	0.011	0.006	0.049	0.055	0.0	0.0	0.0	0.0	0.026	0.38	2.8
7.13	0.006	0.006	0.049	0.055	0.0	0.0	0.0	0.0	0.246	3.66	6.4
8.30	0.011	0.004	0.050	0.058	0.0	0.0	0.0	0.0	0.565	26.67	11.8
9.13	0.023	0.007	0.056	0.057	0.0	0.0	0.0	0.0	0.800	56.64	14.7
10.13	0.021	0.009	0.051	0.060	0.0	0.0	0.0	0.0	0.908	106.11	16.2
11.13	2.000	0.008	0.051	0.059	0.0	0.0	0.0	0.0	1.105	166.30	17.4
12.13	0.124	0.006	0.050	0.060	0.0	0.0	0.0	0.0	0.993	231.73	17.9
13.13	0.152	0.004	0.050	0.060	0.0	0.0	0.0	0.0	0.702	289.09	17.8
14.13	0.161	0.004	0.050	0.060	0.0	0.0	0.0	0.0	0.751	351.54	18.0
15.13	0.163	0.004	0.050	0.060	0.0	0.0	0.0	0.0	0.513	379.74	18.1
16.13	0.171	0.004	0.050	0.059	0.0	0.0	0.0	0.0	0.320	408.05	18.2
17.13					0.0	0.0	0.0	0.0	0.059	421.42	16.3

TIME (ELST)	WAVE- (FT/SEC)	THI (PP/10)	IdR ₁ (PP/10)	IND (PP/10)	1-SOL (PP/1)	20Q ₂ (PP/2)	1-1'-S (100/105)	Cu-S (K-Cu/CuS)	SM (L/MIN)	Cu-SH (LANG)	TEMP (CELSIUS)
0.00	0.0	0.003	0.000	0.010	0.0	0.0			0.0	0.0	
2.13	0.0	0.023	0.0	0.023	1.500	0.0			0.0	0.0	
2.60	0.0	0.023	0.0	0.023					0.0	0.0	
3.93	0.0	0.001	0.0	0.001	1.500				0.0	0.0	
5.47	0.0	0.006	0.001	0.003	1.500				0.0	0.0	
6.63	0.0	0.001	0.005	0.006	1.500		0.690		0.0	0.0	
7.30	0.003	0.002	0.000	0.003	1.500			0.036	1.36		
8.03	0.030	0.005	0.000	0.003	1.500			0.261	7.22		
9.30	0.009	0.020	0.000	0.003	1.500		30.000	0.570	24.42		
10.00	0.057	0.018	0.010	0.000	1.170		39.000	0.550	63.74		
11.30	0.001	0.017	0.010	0.037	1.036	0.160	51.7	0.460	109.45		
12.30	0.009	0.016	0.014	0.035	0.981	0.131		0.730	126.16		10.6
13.67	0.016	0.022	0.030	0.030	0.923	0.130	20.6	1.000	170.40		16.2
14.79	0.015	0.022	0.037	0.037	0.859			1.090	255.06		17.1
15.30	0.080	0.015	0.023	0.035	0.809			0.710	302.90		17.3
16.30	0.073	0.015	0.023	0.036	0.692	0.140		0.650	348.76		17.6
17.30	0.060	0.012	0.023	0.035	0.610	0.123		0.313	377.69		16.7
17.80	0.052	0.011	0.023	0.034		0.073		0.071	392.12		15.6
18.63	0.040	0.011	0.022	0.033	0.510			0.071	398.25		15.6
20.13	0.023	0.011	0.021	0.032	0.473			0.0	395.10		12.3
21.50	0.011	0.010	0.020	0.030		0.010		0.0	395.10		12.2
22.07	0.003	0.011	0.019	0.030	0.403			0.0	395.10		6.0
22.67	0.0	0.010	0.019	0.029	0.390			0.0	395.10		7.1
23.97	0.0	0.010	0.019	0.029	0.390			0.0	395.10		5.0

a/ Interference-corrected initial $[N]$, $[N_2]$, and $[N_x]$ are 0.062, 0.020, and 0.002 ppm.

TIME (HRS)	WIND (MPH)	DIR (DEG)	WIND (MPH)	DIR (DEG)	1-SOL (MPH)	2-SOL (MPH)	1-4-5 (MPH)	U-5 (KNOTS)	SW (L/MIN)	U-SW (KNOTS)	TEMP (CELSIUS)
0.07	0.0	0.010	0.010	0.073	0.597				0.001	0.06	5.2
1.07	0.0	0.011	0.010	0.079	0.506				0.001	0.12	4.6
3.03	0.0	0.017	0.017	0.078	0.577				0.0	0.16	3.6
4.00	0.0	0.009	0.017	0.076	0.566				0.0	0.18	3.1
5.30	0.0	0.010	0.017	0.077	0.561		0.0		0.0	0.18	2.6
6.0	0.0	0.009	0.017	0.076	0.561				0.026	0.05	2.0
7.50	0.0	0.009	0.010	0.075	0.558				0.286	0.17	0.4
8.07	0.015	0.015	0.010	0.031	0.552				0.565	32.43	11.9
9.30	0.010	0.012	0.019	0.031	0.509		0.1		0.600	64.60	14.7
10.30	0.0	0.012	0.021	0.033	0.536			17.500	0.986	116.18	16.2
11.30	0.015	0.012	0.023	0.035	0.576				1.105	177.57	17.9
12.30	0.079	0.010	0.027	0.036	0.504				0.993	241.65	17.9
13.30	0.036	0.008	0.028	0.036	0.276			15.000	0.702	296.20	17.6
14.30	0.008	0.008	0.029	0.037	0.276		5.0		0.751	339.20	18.0
15.30	0.017	0.009	0.029	0.036	0.273				0.513	379.97	18.1
16.30	0.007	0.007	0.031	0.036	0.273			0.0	0.329	401.35	18.2
17.30	0.112	0.007	0.031	0.036	0.273		3.2		0.559	422.02	18.3

RTE SWR, CHAMBER STUDY
USEPA CONTRACT NO. 68-02-2037

CHAMBER NO. 5
DAY 1, 10-3-77
RUN 35 ± 2 MIN-S-H

TIME (EST)	02:00 (PPH)	00 (PPH)	002 (PPH)	000 (PPH)	1-SUL (PPH)	502 (PPH)	1-P-S (UG/H3)	CM-S (K-CM/H3)	SR (L/MIN)	CU-SR (L/UG)	TEMP (CELSIUS)
0.97	0.0	0.003	0.000	0.010	0.0	0.0	0.0		0.0	0.0	
1.63	0.0	0.023	0.0	0.023	1.500	0.0			0.0	0.0	
2.30	0.0	0.002	0.0	0.002	1.500	0.0			0.0	0.0	
3.13	0.0	0.002	0.0	0.002	1.500	0.0			0.0	0.0	
4.53	0.0	0.002	0.0	0.002	1.500	0.0			0.0	0.0	
5.72	0.0	0.002	0.0	0.002	1.500	0.0			0.0	0.0	
6.00	0.0	0.002	0.0	0.002	1.500	0.0			0.0	0.0	
7.47	0.0	0.002	0.0	0.002	1.500	0.0			0.0	0.0	
8.47	0.0	0.002	0.0	0.002	1.500	0.0			0.0	0.0	
9.47	0.0	0.002	0.0	0.002	1.500	0.0			0.0	0.0	
10.47	0.0	0.002	0.0	0.002	1.500	0.0			0.0	0.0	
11.47	0.0	0.002	0.0	0.002	1.500	0.0			0.0	0.0	
12.47	0.0	0.002	0.0	0.002	1.500	0.0			0.0	0.0	
13.47	0.0	0.002	0.0	0.002	1.500	0.0			0.0	0.0	
14.47	0.0	0.002	0.0	0.002	1.500	0.0			0.0	0.0	
15.47	0.0	0.002	0.0	0.002	1.500	0.0			0.0	0.0	
16.47	0.0	0.002	0.0	0.002	1.500	0.0			0.0	0.0	
17.47	0.0	0.002	0.0	0.002	1.500	0.0			0.0	0.0	
18.47	0.0	0.002	0.0	0.002	1.500	0.0			0.0	0.0	
19.47	0.0	0.002	0.0	0.002	1.500	0.0			0.0	0.0	
20.47	0.0	0.002	0.0	0.002	1.500	0.0			0.0	0.0	
21.47	0.0	0.002	0.0	0.002	1.500	0.0			0.0	0.0	
22.47	0.0	0.002	0.0	0.002	1.500	0.0			0.0	0.0	
23.47	0.0	0.002	0.0	0.002	1.500	0.0			0.0	0.0	

a/ Interference-corrected Initial [NO], [NO₂], and [NO_x] are 0.750, 0.230, and 0.980 ppm.

DAY 2, 10-4-77

76 ± SUNSHINE

TIME (EST)	02:00 (PPH)	00 (PPH)	002 (PPH)	000 (PPH)	1-SUL (PPH)	502 (PPH)	1-P-S (UG/H3)	CM-S (K-CM/H3)	SR (L/MIN)	CU-SR (L/UG)	TEMP (CELSIUS)
0.13	0.160	0.002	0.160	0.160	0.0	0.0			0.001	0.01	5.2
1.13	0.153	0.002	0.153	0.153	0.0	0.0			0.001	0.01	4.6
2.13	0.147	0.003	0.147	0.147	0.0	0.0			0.001	0.01	3.9
3.13	0.136	0.002	0.136	0.136	0.0	0.0			0.0	0.0	3.6
4.13	0.131	0.002	0.131	0.131	0.0	0.0			0.0	0.0	3.1
5.13	0.129	0.002	0.129	0.129	0.0	0.0			0.0	0.0	2.6
6.13	0.124	0.001	0.124	0.124	0.0	0.0			0.0	0.0	2.8
7.13	0.119	0.002	0.119	0.119	0.0	0.0			0.0	0.0	2.8
8.13	0.116	0.003	0.116	0.116	0.0	0.0			0.0	0.0	2.8
9.13	0.113	0.003	0.113	0.113	0.0	0.0			0.0	0.0	2.8
10.13	0.114	0.003	0.114	0.114	0.0	0.0			0.0	0.0	2.8
11.13	0.106	0.004	0.106	0.106	0.0	0.0			0.0	0.0	2.8
12.13	0.104	0.004	0.104	0.104	0.0	0.0			0.0	0.0	2.8
13.13	0.101	0.004	0.101	0.101	0.0	0.0			0.0	0.0	2.8
14.13	0.101	0.004	0.101	0.101	0.0	0.0			0.0	0.0	2.8
15.13	0.101	0.004	0.101	0.101	0.0	0.0			0.0	0.0	2.8
16.13	0.101	0.004	0.101	0.101	0.0	0.0			0.0	0.0	2.8
17.13	0.101	0.004	0.101	0.101	0.0	0.0			0.0	0.0	2.8

CONFIDENTIAL
 DAY 1, 10-5-17
 RUN 35 : 12105-5-11

TIME (H:ST)	WZWD (PPH)	WZ (PPH)	WZ ₂ (PPH)	WZ ₃ (PPH)	WZ ₄ (PPH)	WZ ₅ (PPH)	WZ ₆ (PPH)	WZ ₇ (PPH)	WZ ₈ (PPH)	WZ ₉ (PPH)	WZ ₁₀ (PPH)	WZ ₁₁ (PPH)	WZ ₁₂ (PPH)	WZ ₁₃ (PPH)	WZ ₁₄ (PPH)	WZ ₁₅ (PPH)	WZ ₁₆ (PPH)	WZ ₁₇ (PPH)	WZ ₁₈ (PPH)	WZ ₁₉ (PPH)	WZ ₂₀ (PPH)	WZ ₂₁ (PPH)	WZ ₂₂ (PPH)	WZ ₂₃ (PPH)	WZ ₂₄ (PPH)	WZ ₂₅ (PPH)	WZ ₂₆ (PPH)	WZ ₂₇ (PPH)	WZ ₂₈ (PPH)	WZ ₂₉ (PPH)	WZ ₃₀ (PPH)	WZ ₃₁ (PPH)	WZ ₃₂ (PPH)	WZ ₃₃ (PPH)	WZ ₃₄ (PPH)	WZ ₃₅ (PPH)	WZ ₃₆ (PPH)	WZ ₃₇ (PPH)	WZ ₃₈ (PPH)	WZ ₃₉ (PPH)	WZ ₄₀ (PPH)	WZ ₄₁ (PPH)	WZ ₄₂ (PPH)	WZ ₄₃ (PPH)	WZ ₄₄ (PPH)	WZ ₄₅ (PPH)	WZ ₄₆ (PPH)	WZ ₄₇ (PPH)	WZ ₄₈ (PPH)	WZ ₄₉ (PPH)	WZ ₅₀ (PPH)	WZ ₅₁ (PPH)	WZ ₅₂ (PPH)	WZ ₅₃ (PPH)	WZ ₅₄ (PPH)	WZ ₅₅ (PPH)	WZ ₅₆ (PPH)	WZ ₅₇ (PPH)	WZ ₅₈ (PPH)	WZ ₅₉ (PPH)	WZ ₆₀ (PPH)	WZ ₆₁ (PPH)	WZ ₆₂ (PPH)	WZ ₆₃ (PPH)	WZ ₆₄ (PPH)	WZ ₆₅ (PPH)	WZ ₆₆ (PPH)	WZ ₆₇ (PPH)	WZ ₆₈ (PPH)	WZ ₆₉ (PPH)	WZ ₇₀ (PPH)	WZ ₇₁ (PPH)	WZ ₇₂ (PPH)	WZ ₇₃ (PPH)	WZ ₇₄ (PPH)	WZ ₇₅ (PPH)	WZ ₇₆ (PPH)	WZ ₇₇ (PPH)	WZ ₇₈ (PPH)	WZ ₇₉ (PPH)	WZ ₈₀ (PPH)	WZ ₈₁ (PPH)	WZ ₈₂ (PPH)	WZ ₈₃ (PPH)	WZ ₈₄ (PPH)	WZ ₈₅ (PPH)	WZ ₈₆ (PPH)	WZ ₈₇ (PPH)	WZ ₈₈ (PPH)	WZ ₈₉ (PPH)	WZ ₉₀ (PPH)	WZ ₉₁ (PPH)	WZ ₉₂ (PPH)	WZ ₉₃ (PPH)	WZ ₉₄ (PPH)	WZ ₉₅ (PPH)	WZ ₉₆ (PPH)	WZ ₉₇ (PPH)	WZ ₉₈ (PPH)	WZ ₉₉ (PPH)	WZ ₁₀₀ (PPH)	WZ ₁₀₁ (PPH)	WZ ₁₀₂ (PPH)	WZ ₁₀₃ (PPH)	WZ ₁₀₄ (PPH)	WZ ₁₀₅ (PPH)	WZ ₁₀₆ (PPH)	WZ ₁₀₇ (PPH)	WZ ₁₀₈ (PPH)	WZ ₁₀₉ (PPH)	WZ ₁₁₀ (PPH)	WZ ₁₁₁ (PPH)	WZ ₁₁₂ (PPH)	WZ ₁₁₃ (PPH)	WZ ₁₁₄ (PPH)	WZ ₁₁₅ (PPH)	WZ ₁₁₆ (PPH)	WZ ₁₁₇ (PPH)	WZ ₁₁₈ (PPH)	WZ ₁₁₉ (PPH)	WZ ₁₂₀ (PPH)	WZ ₁₂₁ (PPH)	WZ ₁₂₂ (PPH)	WZ ₁₂₃ (PPH)	WZ ₁₂₄ (PPH)	WZ ₁₂₅ (PPH)	WZ ₁₂₆ (PPH)	WZ ₁₂₇ (PPH)	WZ ₁₂₈ (PPH)	WZ ₁₂₉ (PPH)	WZ ₁₃₀ (PPH)	WZ ₁₃₁ (PPH)	WZ ₁₃₂ (PPH)	WZ ₁₃₃ (PPH)	WZ ₁₃₄ (PPH)	WZ ₁₃₅ (PPH)	WZ ₁₃₆ (PPH)	WZ ₁₃₇ (PPH)	WZ ₁₃₈ (PPH)	WZ ₁₃₉ (PPH)	WZ ₁₄₀ (PPH)	WZ ₁₄₁ (PPH)	WZ ₁₄₂ (PPH)	WZ ₁₄₃ (PPH)	WZ ₁₄₄ (PPH)	WZ ₁₄₅ (PPH)	WZ ₁₄₆ (PPH)	WZ ₁₄₇ (PPH)	WZ ₁₄₈ (PPH)	WZ ₁₄₉ (PPH)	WZ ₁₅₀ (PPH)	WZ ₁₅₁ (PPH)	WZ ₁₅₂ (PPH)	WZ ₁₅₃ (PPH)	WZ ₁₅₄ (PPH)	WZ ₁₅₅ (PPH)	WZ ₁₅₆ (PPH)	WZ ₁₅₇ (PPH)	WZ ₁₅₈ (PPH)	WZ ₁₅₉ (PPH)	WZ ₁₆₀ (PPH)	WZ ₁₆₁ (PPH)	WZ ₁₆₂ (PPH)	WZ ₁₆₃ (PPH)	WZ ₁₆₄ (PPH)	WZ ₁₆₅ (PPH)	WZ ₁₆₆ (PPH)	WZ ₁₆₇ (PPH)	WZ ₁₆₈ (PPH)	WZ ₁₆₉ (PPH)	WZ ₁₇₀ (PPH)	WZ ₁₇₁ (PPH)	WZ ₁₇₂ (PPH)	WZ ₁₇₃ (PPH)	WZ ₁₇₄ (PPH)	WZ ₁₇₅ (PPH)	WZ ₁₇₆ (PPH)	WZ ₁₇₇ (PPH)	WZ ₁₇₈ (PPH)	WZ ₁₇₉ (PPH)	WZ ₁₈₀ (PPH)	WZ ₁₈₁ (PPH)	WZ ₁₈₂ (PPH)	WZ ₁₈₃ (PPH)	WZ ₁₈₄ (PPH)	WZ ₁₈₅ (PPH)	WZ ₁₈₆ (PPH)	WZ ₁₈₇ (PPH)	WZ ₁₈₈ (PPH)	WZ ₁₈₉ (PPH)	WZ ₁₉₀
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a/ Interference-corrected initial $[\text{NO}]$, $[\text{NO}_2]$, and $[\text{NO}_x]$ are 0.368, 0.129, and 0.497 ppm.

[illegible]

RTI SHUG CHAMBER STUDY
USELPA CONTRACT NO. 68-02-2437

CHAMBER NO. 1
DAY 1, 10-5-77
RUN 34 I (CH3S)2

99 X SUNSHINE

TIME (EST)	OZONE (PPH)	NO (PPH)	NO2 (PPH)	NOX (PPH)	T-SUL (PPH)	SO2 (PPH)	T-P-S (UG/H3)	PAN (PPH)	CN-S (K-CN/CH3)	SR (L/MIN)	CU-SR (LANG) CELSIUS	TEMP (L/MIN) CELSIUS
0.00	0.0	0.002	0.003	0.005	0.0	0.0				0.0	0.0	5.1
1.00	0.0	0.149	0.0	0.149	1.500	0.0				0.0	0.0	0.0
2.30	0.0	0.155 a/	0.035 a/	0.190 a/	1.500	0.0			0.0	0.0	0.0	4.5
3.27	0.0	0.156	0.040	0.193	1.500	0.0	0.0			0.0	0.0	3.9
4.40	0.0	0.154	0.040	0.193	1.500	0.0				0.0	0.0	3.4
5.13	0.0	0.057	0.102	0.158	1.500	0.065				0.0	0.0	2.9
6.13	0.0	0.024	0.066	0.091	1.500	0.379	502.4	0.0		0.027	0.21	2.6
8.13	0.004	0.010	0.029	0.040	0.859	0.662				0.256	3.62	5.4
9.30	0.080	0.007	0.012	0.019	0.752	0.608	23.000			0.556	21.32	9.9
10.63	0.100	0.006	0.013	0.021	0.542	0.432	230.9			0.960	64.36	14.2
11.63	0.107	0.011	0.011	0.022	0.525	0.421				1.067	133.37	17.3
12.13	0.118	0.009	0.010	0.019	0.492	0.392	127.9			1.056	195.01	18.9
13.13	0.129	0.008	0.011	0.019	0.448	0.354				0.947	226.94	19.6
14.13	0.129	0.006	0.011	0.016	0.423	0.327				0.785	289.45	20.4
15.13	0.129	0.006	0.011	0.016	0.423	0.327	148.9			0.561	353.01	20.3
16.13	0.121	0.004	0.009	0.014	0.397	0.312				0.291	421.91	20.7
17.13	0.105	0.002	0.010	0.013	0.329	0.260				0.052	437.50	18.7
18.13	0.089	0.001	0.012	0.013	0.230		65.4			0.0	440.22	14.8
19.47	0.071	0.002	0.010	0.012						0.0	440.22	14.8
20.13	0.064	0.002	0.009	0.010						0.0	440.22	12.6
21.13	0.054	0.001	0.008	0.008						0.0	440.22	11.3
22.13	0.046	0.0	0.006	0.006						0.0	440.22	10.3
23.47	0.037	0.0	0.006	0.006						0.0	440.22	9.4
										0.0	440.22	8.7

a/ Consider this value to be the interference-corrected initial concentration.

DAY 2, 10-6-77

29 X SUNSHINE

TIME (EST)	OZONE (PPH)	NO (PPH)	NO2 (PPH)	NOX (PPH)	T-SUL (PPH)	SO2 (PPH)	T-P-S (UG/H3)	PAN (PPH)	CN-S (K-CN/CH3)	SR (L/MIN)	CU-SR (LANG) CELSIUS	TEMP (L/MIN) CELSIUS
0.47	0.033	0.0	0.006	0.006						0.0	0.0	8.2
1.47	0.027	0.0	0.006	0.006						0.0	0.0	7.8
2.97	0.021	0.0	0.006	0.006						0.001	0.06	7.5
3.97	0.016	0.0	0.006	0.006						0.0	0.06	7.3
4.97	0.014	0.000	0.006	0.007						0.0	0.06	7.2
5.97	0.011	0.0	0.007	0.007						0.0	0.06	7.5
6.80	0.008	0.002	0.006	0.007						0.040	1.98	7.6
7.47	0.007	0.002	0.007	0.009			8.9			0.155	6.83	10.3
8.13	0.007	0.002	0.007	0.009						0.407	14.93	13.4
9.13	0.015	0.002	0.008	0.010						0.663	41.35	16.8
10.13	0.029	0.002	0.009	0.011						0.541	80.18	18.7
11.13	0.083	0.004	0.010	0.014						0.926	115.64	20.4
12.13	0.074	0.007	0.011	0.018			3.6		1.000	0.979	171.62	21.9
13.13	0.104	0.007	0.011	0.018						0.637	227.69	22.6
14.13	0.114	0.008	0.013	0.021						0.417	264.19	22.8
15.13	0.114	0.008	0.012	0.019	0.135	0.043				0.276	288.11	21.6
16.13	0.105	0.005	0.012	0.019	0.118	0.074				0.191	304.01	19.8
17.13			0.011	0.017	0.099	0.059	0.0			0.035	314.25	18.7

RTI SHOG CHAMBER STUDY
USLPA CONTRACT NO. 68-02-2437

CHAMBER NO. 2
DAY 1, 10-5-77
RUN 34 1 (CH3)2

TIME (EST)	OZONE (PPM)	NO (PPM)	NO2 (PPM)	NOX (PPM)	99 X SUNSHINE T-SUL (PPM)	S02 (PPM)	T-P-S (UG/M3)	PAN (PPM)	CH-S (K-CN/CM3)	SR (L/MIN)	CU-SR (LANG) CELSIUS	TEMP CELSIUS
0.97	0.0	0.004	0.004	0.008	0.0	0.0				0.0	0.0	5.1
1.97					1.500	0.0				0.0	0.0	4.5
2.47					1.500	0.0				0.0	0.0	3.9
3.47	0.0	0.070	0.0	0.070	0.0	0.0			0.0	0.0	0.0	3.4
4.63	0.0	0.074a/	0.017a/	0.091a/	1.500	0.0	0.0		0.0	0.0	0.0	2.9
5.30	0.0	0.073	0.018	0.091	1.500	0.0				0.0	0.0	2.6
6.30	0.0	0.073	0.017	0.089	1.500	0.0				0.0	0.0	2.6
7.30	0.0	0.013	0.050	0.062	1.500	0.010				0.027	0.49	2.6
8.30	0.0	0.012	0.028	0.039	1.500	0.192	156.7			0.256	6.23	5.4
9.47	0.001	0.010	0.010	0.020	1.500	0.387			18.500	0.556	26.99	9.9
10.60	0.002	0.011	0.006	0.017	1.094	0.514	177.4	0.0	19.000	0.779	72.31	14.2
11.80	0.020	0.011	0.008	0.019	0.638	0.497		0.0		0.960	143.16	17.3
12.30	0.022	0.010	0.008	0.018	0.601	0.404	107.6	0.0	22.000	1.067	205.90	18.9
13.30	0.019	0.010	0.009	0.018	0.547	0.439		0.0		0.947	237.71	19.8
14.47	0.104	0.008	0.009	0.016	0.489	0.393		0.0	2.100	0.785	299.11	20.4
15.30	0.112	0.005	0.009	0.015	0.457	0.365	107.8	0.0		0.561	361.02	20.8
16.30	0.109	0.004	0.008	0.012	0.420	0.333		0.0	1.200	0.291	396.08	20.3
17.30	0.096	0.002	0.009	0.011	0.276	0.267		0.0		0.052	424.88	20.7
18.30	0.083	0.001	0.010	0.011				0.0		0.0	438.04	18.7
18.80	0.078	0.002	0.010	0.012				0.0		0.0	440.22	14.8
19.63	0.069	0.003	0.008	0.011				0.0		0.0	440.22	12.6
20.30	0.064	0.002	0.008	0.011				0.0		0.0	440.22	11.3
21.30	0.055	0.000	0.007	0.007				0.0		0.0	440.22	10.3
22.30	0.049	0.0	0.006	0.006				0.0		0.0	440.22	9.4
23.63	0.043	0.	0.006	0.006				0.0		0.0	440.22	8.7

a/ Consider this value to be the interference-corrected initial concentration.

DAY 2, 10-6-77

29 X SUNSHINE

TIME (EST)	OZONE (PPM)	NO (PPM)	NO2 (PPM)	NOX (PPM)	99 X SUNSHINE T-SUL (PPM)	S02 (PPM)	T-P-S (UG/M3)	PAN (PPM)	CH-S (K-CN/CM3)	SR (L/MIN)	CU-SR (LANG) CELSIUS	TEMP CELSIUS
0.63	0.037	0.0	0.005	0.005				0.0		0.0	0.0	8.2
1.63	0.033	0.0	0.005	0.005				0.0		0.0	0.0	7.8
2.13	0.032	0.0	0.005	0.005				0.0		0.001	0.01	7.5
3.13	0.027	0.0	0.005	0.005				0.0		0.0	0.06	7.3
4.13	0.024	0.0	0.005	0.005				0.0		0.0	0.06	7.2
5.13	0.021	0.0	0.006	0.006				0.0		0.0	0.06	7.5
6.13	0.019	0.000	0.006	0.006				0.0		0.040	0.37	7.6
7.63	0.015	0.001	0.005	0.006			0.0	0.0		0.155	6.32	10.3
8.30	0.016	0.003	0.007	0.010				0.0		0.407	19.09	13.4
9.30	0.023	0.002	0.008	0.010				0.0		0.663	48.11	16.8
10.30	0.036	0.002	0.008	0.010				0.0		0.541	85.70	18.7
11.30	0.052	0.005	0.009	0.014				0.0		0.926	125.09	20.4
12.30	0.087	0.008	0.011	0.019			0.0	0.0	0.690	0.979	181.60	21.9
13.30	0.117	0.007	0.012	0.019				0.0		0.637	234.19	22.6
14.30	0.124	0.008	0.012	0.020				0.0		0.417	268.45	22.8
15.30	0.125	0.007	0.012	0.018	0.095	0.010		0.0		0.276	290.93	21.6
16.30	0.116	0.005	0.011	0.017	0.081	0.010		0.0		0.191	305.96	19.8
17.30					0.058	0.010	4.5		0.0	0.035	314.61	18.7

RTI SMOG CHAMBER STUDY
USEPA CONTRACT NO. 68-02-2437

CHAMBER NO. 3
DAY 1, 10-5-77
RUN 34 1 (CH33)2

99 X SUNSHINE

TIME (EST)	OZONE (PPH)	NO (PPH)	NO2 (PPH)	NOX (PPH)	T-SUL (PPH)	SU2 (PPH)	T-P-S (UG/M3)	PAN (PPH)	CN-5 (K-CN/CM3)	SR (L/MIN)	CU-SR (LANG) CELSIUS	TEMP CELSIUS
0.47	0.0	0.006	0.004	0.010	0.0	0.0				0.0	0.0	5.1
1.13	0.0	0.006	0.004	0.010	0.0	0.0				0.0	0.0	4.5
2.77	0.0	0.006	0.004	0.010	0.0	0.0				0.0	0.0	3.9
3.67	0.0	0.006	0.004	0.010	0.0	0.0				0.0	0.0	3.4
4.60	0.0	0.006	0.004	0.010	0.0	0.0			0.0	0.0	0.0	2.9
5.47	0.0	0.006	0.004	0.010	0.0	0.0				0.0	0.0	2.6
6.47	0.0	0.006	0.004	0.010	0.0	0.0				0.027	0.76	2.6
7.47	0.003	0.003	0.003	0.003	0.003	0.003				0.256	0.64	5.4
8.47	0.054	0.034	0.045	0.078	0.078	0.078	276.3	0.0		0.556	32.66	9.9
9.63	0.056	0.044	0.044	0.044	0.044	0.044	146.3	0.0	22.000	0.779	79.79	14.2
10.97	0.104	0.024	0.024	0.024	0.024	0.024	146.3	0.0	23.000	0.960	152.95	17.3
11.97	0.221	0.011	0.011	0.011	0.011	0.011	174.6	0.0		1.067	216.78	18.9
12.47	0.267	0.009	0.009	0.009	0.009	0.009		0.0	24.000	1.056	208.48	19.8
13.47	0.376	0.008	0.008	0.008	0.008	0.008		0.0		0.947	304.77	20.4
14.63	0.385	0.007	0.007	0.007	0.007	0.007		0.0	3.600	0.785	368.55	20.8
15.47	0.370	0.005	0.005	0.005	0.005	0.005	68.2	0.0		0.561	401.80	20.3
16.47	0.347	0.003	0.003	0.003	0.003	0.003		0.0		0.291	427.85	20.7
17.47	0.314	0.001	0.001	0.001	0.001	0.001		0.0	1.600	0.052	438.57	18.7
18.47	0.202	0.002	0.002	0.002	0.002	0.002	90.3	0.0		0.0	440.22	14.8
18.97	0.269	0.002	0.002	0.002	0.002	0.002		0.0		0.0	440.22	12.6
19.60	0.251	0.003	0.003	0.003	0.003	0.003		0.0		0.0	440.22	11.3
20.47	0.239	0.001	0.001	0.001	0.001	0.001		0.0		0.0	440.22	10.3
21.47	0.223	0.0	0.0	0.0	0.0	0.0		0.0		0.0	440.22	9.4
22.47	0.209	0.0	0.0	0.0	0.0	0.0		0.0		0.0	440.22	8.7
23.60	0.194	0.0	0.0	0.0	0.0	0.0		0.0		0.0	440.22	

a/ Consider this value to be the interference-corrected initial concentration.

DAY 2, 10-6-77

29 X SUNSHINE

TIME (EST)	OZONE (PPH)	NO (PPH)	NO2 (PPH)	NOX (PPH)	T-SUL (PPH)	SU2 (PPH)	T-P-S (UG/M3)	PAN (PPH)	CN-5 (K-CN/CM3)	SR (L/MIN)	CU-SR (LANG) CELSIUS	TEMP CELSIUS
0.60	0.183	0.0	0.019	0.019				0.0		0.0	0.0	8.2
1.60	0.173	0.0	0.019	0.019				0.0		0.0	0.0	7.6
2.30	0.167	0.0	0.019	0.019				0.0		0.001	0.02	7.5
3.30	0.159	0.0	0.019	0.019				0.0		0.0	0.06	7.3
4.30	0.150	0.0	0.019	0.019				0.0		0.0	0.06	7.2
5.30	0.143	0.0	0.020	0.020				0.0	0.0	0.0	0.06	7.5
6.30	0.134	0.000	0.020	0.020				0.0		0.040	0.76	7.6
7.13	0.126	0.001	0.020	0.020			0.0	0.0		0.155	3.67	10.3
8.47	0.115	0.003	0.021	0.024				0.0		0.407	25.24	13.4
9.47	0.115	0.002	0.023	0.025				0.0		0.663	54.88	16.8
10.47	0.121	0.002	0.024	0.026				0.0		0.581	91.22	18.7
11.47	0.134	0.005	0.025	0.030				0.0		0.826	134.53	20.4
12.47	0.166	0.006	0.027	0.034				0.0	0.750	0.979	191.59	21.9
13.47	0.194	0.007	0.029	0.036	0.072	0.010	4.7	0.0		0.637	240.68	22.6
14.47	0.197	0.007	0.029	0.036	0.062	0.010		0.0		0.417	272.70	22.8
15.47	0.194	0.007	0.028	0.034	0.062	0.010		0.0		0.276	293.74	21.6
16.47	0.180	0.004	0.027	0.032	0.055	0.010		0.0		0.191	307.91	19.8
17.47							3.0			0.035	314.97	16.7

CHAMBER NO. 4
DAY 1, 10-5-77
RUN 34 (CH3S)2

RTI SHUG CHAMBER STUDY
USEPA CONTRACT NO. 68-02-2437

TIME (EST)	OZONE (PPH)	HO (PPH)	NO2 (PPH)	NOX (PPH)	I-SUL (PPH)	SU2 (PPH)	I-P-S (UG/M3)	PAN (PPH)	CN-5 (K-CN/CM3)	SR (L/MIN)	CU-SR (LANG) CELSIUS	TEMP CELSIUS
0.63	0.0	0.003	0.003	0.006	0.0	0.0				0.0	0.0	5.1
1.10	0.0	0.391	0.0	0.391	1.500	0.0				0.0	0.0	4.5
2.60	0.0	0.399 a/	0.094 a/	0.492 a/	1.500	0.0				0.0	0.0	3.9
3.03	0.0	0.393	0.100	0.493	1.500	0.0				0.0	0.0	3.4
4.13	0.0	0.378	0.108	0.486	1.500	0.0	57.0	0.0	0.0	0.0	0.0	2.9
5.63	0.0	0.370	0.290	0.320	0.685	0.495				0.0	0.0	2.6
6.63	0.004	0.030	0.166	0.181	0.478	0.380	182.6	0.0		0.027	1.02	2.6
7.77	0.077	0.014	0.010	0.113	0.393	0.308			19.000	0.256	11.30	5.4
9.80	0.113	0.008	0.043	0.051	0.335	0.225	141.4	0.0	21.000	0.556	42.67	9.9
10.00	0.236	0.009	0.020	0.029	0.235	0.193				0.779	87.73	14.2
11.13	0.311	0.009	0.018	0.026	0.197	0.157	140.9	0.0	24.000	0.960	97.08	17.3
12.63	0.309	0.007	0.016	0.024						1.067	163.00	18.9
13.63	0.296	0.007	0.016	0.024						1.056	258.62	19.8
14.80	0.246	0.007	0.016	0.024					2.600	0.947	317.86	20.4
15.00	0.264	0.003	0.015	0.018			154.3	0.0		0.785	376.56	20.8
16.63	0.262	0.001	0.016	0.017				0.0		0.561	385.98	20.3
17.63	0.215	0.002	0.013	0.015			47.9	0.0	2.500	0.291	430.64	20.7
18.00	0.204	0.003	0.011	0.014				0.0		0.052	439.06	18.7
19.13	0.198	0.002	0.012	0.012				0.0		0.0	440.22	14.8
20.63	0.189	0.0	0.011	0.011				0.0		0.0	440.22	12.6
21.63	0.180	0.0	0.011	0.011				0.0		0.0	440.22	11.3
22.63	0.169	0.0	0.010	0.010				0.0		0.0	440.22	10.3
23.97	0.152	0.003	0.017	0.021				0.0		0.0	440.22	9.4
								0.0		0.0	440.22	8.7

a/ Consider this value to be the interference-corrected initial concentration.

DAY 2, 10-6-77

TIME (EST)	OZONE (PPH)	HO (PPH)	NO2 (PPH)	NOX (PPH)	I-SUL (PPH)	SU2 (PPH)	I-P-S (UG/M3)	PAN (PPH)	CN-5 (K-CN/CM3)	SR (L/MIN)	CU-SR (LANG) CELSIUS	TEMP CELSIUS
0.97	0.163	0.0	0.010	0.010				0.0		0.0	0.0	8.2
2.47	0.151	0.0	0.009	0.009				0.0		0.001	0.03	7.5
3.63	0.137	0.0	0.009	0.009				0.0		0.0	0.06	7.3
4.47	0.131	0.0	0.010	0.010				0.0		0.0	0.06	7.2
5.47	0.125	0.0	0.010	0.010				0.0	0.0	0.0	0.06	7.5
6.47	0.120	0.0	0.010	0.010				0.0		0.040	1.19	7.6
7.30	0.110	0.003	0.011	0.014			0.0	0.0		0.155	5.25	10.3
8.63	0.109	0.002	0.013	0.015				0.0		0.407	27.14	13.4
9.63	0.112	0.003	0.015	0.018				0.0		0.663	61.24	16.6
10.63	0.124	0.008	0.016	0.024				0.0		0.541	96.41	18.7
11.63	0.150	0.008	0.018	0.026				0.0		0.926	141.42	20.4
12.63	0.166	0.010	0.018	0.028			0.0	0.0	0.810	0.979	200.99	21.9
13.63	0.166	0.008	0.019	0.027	0.010	0.010		0.0		0.637	246.40	22.6
14.63	0.163	0.008	0.018	0.024	0.010	0.010		0.0		0.417	276.70	22.8
15.63	0.152	0.003	0.017	0.021	0.010	0.010		0.0		0.276	296.39	21.6
16.63									0.0	0.191	309.74	19.8
17.63							3.2			0.035	315.30	18.7

RTI SMOG CHAMBER STUDY
USEPA CONTRACT NO. 68-02-2437

CHAMBER NO. 1
DAY 1, 10-7-77
RUN 35 : (C2H5SS)2

34 X SUNSHINE

TIME (EST)	OZONE (PPM)	NO (PPM)	NO2 (PPM)	NOX (PPH)	I-SUL (PPM)	SO2 (PPH)	I-P-S (UG/M3)	PAN (PPH)	CN-5 (K-CN/CM3)	SR (L/MIN)	CU-SR (LANG)	TEMP (CELSIUS)
0.13	0.0	0.003	0.002	0.004	0.0	0.0	0.0	0.001	1.300	0.033	0.0	14.6
1.13	0.0	0.001	0.002	0.003	0.0	0.0	0.0	0.0		0.0	0.0	12.6
3.07	0.0	0.153	0.0	0.153	0.0	0.0	0.0	0.0		0.0	0.0	12.4
3.93	0.0	0.159	0.038	0.197	0.0	0.0	0.0	0.0		0.0	0.0	11.7
4.30	0.0	0.155	0.037	0.192	1.500	0.0	0.0	0.001		0.0	0.0	10.8
5.13	0.0	0.154a/	0.037a/	0.191a/	1.500	0.0	0.0	0.0		0.033	0.26	10.8
6.13	0.0	0.026	0.122	0.148	1.500	0.0	0.0	0.0	41.000	0.202	3.56	12.6
7.13	0.0	0.018	0.076	0.094	1.500	0.0	104.8	0.000		0.431	17.46	14.5
8.13	0.0	0.008	0.068	0.076	0.869	0.409	0.0	0.027		0.646	45.00	16.5
9.13	0.008	0.005	0.070	0.075	0.703	0.549	55.6	0.051	56.000	0.930	85.97	18.4
10.13	0.037	0.004	0.075	0.079	0.690	0.552	20.0	0.047		0.995	142.28	19.6
11.13	0.078	0.004	0.079	0.083	0.661	0.533	0.0	0.045		0.985	201.90	20.3
12.13	0.118	0.004	0.078	0.082	0.635	0.513	0.0	0.044		0.888	260.25	20.6
13.13	0.155	0.004	0.080	0.082	0.594	0.474	0.0	0.038		0.509	310.57	20.5
14.13	0.183	0.002	0.080	0.083	0.559	0.414	17.9	0.044	2.100	0.411	340.35	20.6
15.13	0.189	0.003	0.080	0.081	0.511	0.326	6.7	0.040		0.163	363.07	19.6
16.13	0.185	0.003	0.077	0.080	0.408	0.203	0.0	0.042	1.700	0.027	371.79	17.3
17.13	0.168	0.003	0.075	0.079	0.246	0.0	0.0	0.040		0.0	373.20	15.1
18.13	0.146	0.004	0.075	0.076	0.0	0.0	0.0	0.035		0.001	373.21	13.6
19.13	0.125	0.004	0.072	0.076	0.0	0.0	0.0	0.032		0.002	373.27	13.3
20.13	0.106	0.004	0.072	0.074	0.0	0.0	0.0	0.037		0.003	373.40	14.1
21.13	0.091	0.004	0.070	0.073	0.0	0.0	0.0	0.037		0.003	373.58	13.9
22.13	0.074	0.003	0.071	0.073	0.0	0.0	0.0	0.037		0.003		
23.13	0.060	0.002	0.069	0.070	0.0	0.0	0.0	0.037		0.003		

a/ Data Insufficient to permit correction for interference.

DAY 2, 10-8-77

29 X SUNSHINE

TIME (EST)	OZONE (PPH)	NO (PPM)	NO2 (PPM)	NOX (PPH)	I-SUL (PPM)	SO2 (PPH)	I-P-S (UG/M3)	PAN (PPH)	CN-5 (K-CN/CM3)	SR (L/MIN)	CU-SR (LANG)	TEMP (CELSIUS)
0.13	0.047	0.001	0.068	0.069	0.034	0.0	0.0	0.034		0.003	0.02	13.7
1.13	0.035	0.001	0.067	0.068	0.034	0.0	0.0	0.034		0.002	0.20	13.6
2.13	0.026	0.002	0.066	0.068	0.033	0.0	0.0	0.033		0.003	0.32	13.4
3.13	0.020	0.001	0.067	0.068	0.031	0.0	0.0	0.031		0.003	0.50	13.4
4.13	0.015	0.002	0.066	0.068	0.031	0.0	0.0	0.031		0.003	0.68	13.6
5.13	0.011	0.002	0.065	0.067	0.031	0.0	0.0	0.031	0.0	0.003	0.86	13.6
6.13	0.008	0.002	0.063	0.065	0.029	0.0	0.0	0.029		0.008	1.08	13.3
7.13	0.007	0.002	0.064	0.066	0.030	0.0	0.0	0.030		0.049	1.88	13.4
8.13	0.008	0.001	0.064	0.065	0.031	0.0	0.0	0.031		0.150	5.61	13.9
9.13	0.015	0.0	0.063	0.063	0.030	0.0	0.0	0.030		0.250	15.19	15.1
10.13	0.027	0.0	0.067	0.067	0.038	0.0	0.0	0.038		0.355	31.21	16.8
11.13	0.042	0.0	0.068	0.068	0.045	0.0	0.0	0.045	5.700	0.319	52.23	17.4
12.13	0.054	0.0	0.070	0.070	0.048	0.0	0.0	0.048		0.133	69.92	18.0
13.13	0.055	0.000	0.070	0.071	0.050	0.0	0.0	0.050		0.092	77.58	17.9
14.13	0.054	0.0	0.069	0.069	0.049	0.0	0.0	0.049		0.052	82.79	16.8
15.13	0.047	0.000	0.071	0.071	0.049	0.0	20.3	0.049		0.034	85.77	16.2
16.13	0.041	0.000	0.070	0.070	0.048	0.0	0.0	0.048	2.600	0.036	87.82	16.1

RTI SHOG CHAMBER STUDY
USEPA CONTRACT NO. 68-02-2437

CHAMBER NO. 2
DAY 1, 10-1-77
RUN 35 I (C2H5S)2

34 % SUNSHINE

TIME (EST)	OZONE (PPH)	NO (PPH)	NO2 (PPH)	NOX (PPH)	T-SUL (PPH)	SU2 (PPH)	T-P-S (UG/M3)	PAN (PPH)	CH-S (K-CN/CM3)	SR (L/MIN)	CU-SR (LANG) CELSIUS	TEMP (LANG) CELSIUS
0.30	0.0	0.002	0.003	0.006	0.0	0.0	0.0	0.0		0.0	0.0	14.6
1.30	0.0	0.001	0.003	0.004	0.0	0.0				0.0	0.0	12.6
3.27	0.0	0.074	0.0	0.074	1.500	0.0			3.500	0.0	0.0	12.4
4.13	0.0	0.075	0.020	0.095	1.500	0.0				0.0	0.0	11.7
4.47	0.0	0.075	0.019	0.094						0.0	0.0	11.7
5.30	0.0	0.074	0.020	0.094	1.500	0.0	0.0	0.0		0.0	0.0	10.8
6.30	0.0	0.072	0.020	0.093	1.500	0.0				0.033	0.59	10.8
7.30	0.0	0.017	0.041	0.058	1.333	0.089	77.3	0.0	32.500	0.202	5.62	12.6
8.30	0.0	0.015	0.025	0.040	1.078	0.195		0.000		0.431	21.66	14.5
9.30	0.001	0.013	0.020	0.033	0.876	0.425		0.005		0.646	51.59	16.5
10.30	0.002	0.008	0.024	0.032	0.837	0.566	10.6	0.017	41.000	0.930	95.46	18.4
11.30	0.031	0.085	0.029	0.038	0.813	0.611	17.5	0.023		0.995	152.43	19.6
12.30	0.053	0.004	0.034	0.038	0.778	0.614		0.027		0.985	211.95	20.3
13.30	0.077	0.004	0.036	0.040	0.741	0.600		0.040		0.888	269.30	20.6
14.30	0.095	0.002	0.040	0.042	0.698	0.568	7.7	0.030	1.400	0.509	315.76	20.5
15.30	0.104	0.002	0.040	0.042	0.676	0.553		0.040		0.411	344.54	20.6
16.30	0.102	0.003	0.039	0.042	0.622	0.507	4.3	0.026	0.950	0.163	368.73	19.6
17.30	0.093	0.003	0.036	0.041	0.497	0.397		0.028		0.027	372.07	17.3
18.30	0.080	0.004	0.037	0.041	0.242	0.200		0.024		0.0	373.20	15.1
19.30	0.066	0.005	0.036	0.041				0.023		0.0	373.20	14.6
20.30	0.055	0.005	0.036	0.041				0.018		0.001	373.22	13.6
21.30	0.046	0.004	0.035	0.039				0.018		0.002	373.29	13.3
22.30	0.038	0.002	0.035	0.037				0.015		0.003	373.43	14.1
23.30	0.031	0.002	0.035	0.036				0.017		0.003	373.61	13.9

a/ Data Insufficient to permit correction for interference.

DAY 2, 10-8-77

29 % SUNSHINE

TIME (EST)	OZONE (PPH)	NO (PPH)	NO2 (PPH)	NOX (PPH)	T-SUL (PPH)	SU2 (PPH)	T-P-S (UG/M3)	PAN (PPH)	CH-S (K-CN/CM3)	SR (L/MIN)	CU-SR (LANG) CELSIUS	TEMP (LANG) CELSIUS
0.30	0.024	0.001	0.036	0.037				0.019		0.003	0.05	13.7
1.30	0.019	0.001	0.034	0.035				0.022		0.002	0.22	13.6
2.30	0.015	0.001	0.035	0.036				0.020		0.003	0.35	13.4
3.30	0.011	0.002	0.033	0.035				0.024		0.003	0.53	13.4
4.30	0.008	0.001	0.034	0.035				0.018		0.003	0.71	13.6
5.30	0.006	0.002	0.034	0.036				0.026	0.0	0.003	0.89	13.6
6.30	0.005	0.001	0.034	0.035			3.1	0.022		0.008	1.16	13.3
7.30	0.004	0.001	0.034	0.035				0.017		0.049	2.38	13.4
8.30	0.006	0.001	0.035	0.036				0.017		0.150	7.14	13.9
9.30	0.012	0.0	0.036	0.036				0.018		0.250	17.94	15.1
10.30	0.023	0.0	0.040	0.040				0.026		0.355	34.83	16.4
11.30	0.034	0.0	0.042	0.042				0.033		0.319	55.48	17.4
12.30	0.043	0.0	0.045	0.045			0.0	0.033	2.950	0.133	71.27	18.0
13.30	0.044	0.0	0.046	0.046				0.034		0.092	78.52	17.9
14.30	0.045	0.0	0.045	0.045				0.033		0.052	83.12	16.8
15.30	0.042	0.000	0.046	0.046			0.0	0.036		0.034	86.11	16.2
16.30	0.037	0.000	0.046	0.046				0.035	3.100	0.036	86.19	16.1

R11 SMOG CHAMBER STUDY
USIPA CONTRACT NO. 68-02-2437

CHAMBER NO. 3
DAY 1, 10-7-77
RUN 35 1 (C2H5S)2

TIME (EST)	OZONE (PPH)	NO (PPH)	NO2 (PPH)	NOX (PPH)	T-SUL (PPH)	SO2 (PPH)	T-P-S (UG/M3)	PAN (PPH)	CN-S (K-CN/CM3)	SR (L/MIN)	CU-SH (LANG)	TEMP CELSIUS
0.47	0.0	0.002	0.004	0.006	0.0	0.0				0.0	0.0	14.6
1.47	0.0	0.001	0.003	0.004	0.0	0.0				0.0	0.0	12.6
2.57	0.0	0.798	0.0	0.798	0.0	0.0				0.0	0.0	12.0
3.53	0.0	0.797	0.186	0.983	1.500	0.0			2.950	0.0	0.0	12.4
4.63	0.0	0.778	0.202	0.981	1.500	0.0				0.0	0.0	11.7
5.47	0.0	0.763	0.214	0.977	1.500	0.0	0.0	0.0		0.0	0.0	10.8
6.47	0.0	0.716a/	0.229a/	0.965a/	1.500	0.0	0.0	0.0		0.033	0.93	10.8
7.47	0.034	0.033	0.732	0.765	0.867	0.729	231.8	0.0	27.000	0.202	7.68	12.6
8.47	0.085	0.031	0.603	0.634	0.735	0.636		0.102		0.431	26.25	14.5
9.47	0.122	0.022	0.521	0.543	0.669	0.605		0.154		0.646	58.18	16.5
10.47	0.235	0.009	0.446	0.455	0.650	0.563	71.0	0.176	23.000	0.930	104.95	18.4
11.47	0.354	0.005	0.372	0.376	0.644	0.558				0.995	162.58	19.6
12.47	0.460	0.003	0.323	0.326	0.618	0.529	80.1	0.198		0.985	222.00	20.3
13.47	0.531	0.003	0.306	0.308	0.593	0.508		0.200		0.888	278.36	20.6
14.47	0.559	0.002	0.296	0.298	0.569	0.487		0.194	2.700	0.509	320.95	20.5
15.47	0.560	0.002	0.263	0.285	0.555	0.475	47.0	0.186		0.163	366.40	19.6
16.47	0.540	0.003	0.267	0.270	0.505	0.430		0.177	1.000	0.027	372.34	17.3
17.47	0.505	0.004	0.250	0.262	0.394	0.330	34.7	0.166		0.0	373.20	15.1
18.47	0.463	0.004	0.250	0.254	0.206	0.179		0.150		0.0	373.20	14.6
19.47	0.426	0.005	0.246	0.250				0.141		0.001	373.23	13.6
20.47	0.396	0.005	0.239	0.243				0.133		0.002	373.32	13.3
21.47	0.370	0.004	0.235	0.238				0.126		0.003	373.46	14.1
22.47	0.345	0.003	0.232	0.234						0.003	373.64	13.9
23.47	0.322	0.002	0.228	0.230								

a/ Data insufficient to permit correction for interference.

DAY 2, 10-8-77

29 X SUNSHINE

TIME (EST)	OZONE (PPH)	NO (PPH)	NO2 (PPH)	NOX (PPH)	T-SUL (PPH)	SO2 (PPH)	T-P-S (UG/M3)	PAN (PPH)	CN-S (K-CN/CM3)	SR (L/MIN)	CU-SH (LANG)	TEMP CELSIUS
0.47	0.394	0.002	0.223	0.225				0.131		0.003	0.08	13.7
1.47	0.276	0.003	0.221	0.224				0.126		0.002	0.24	13.6
2.47	0.256	0.003	0.219	0.222				0.131		0.003	0.14	13.4
3.47	0.236	0.003	0.215	0.218				0.134		0.003	0.50	13.4
4.47	0.216	0.002	0.213	0.215				0.125		0.003	0.74	13.6
5.47	0.200	0.003	0.210	0.213			0.0	0.122	0.0	0.003	0.92	13.6
6.47	0.182	0.003	0.209	0.212			0.0	0.121		0.004	1.25	13.3
7.47	0.167	0.002	0.208	0.210				0.118		0.049	2.04	13.4
8.47	0.156	0.001	0.209	0.210				0.122		0.150	8.67	13.9
9.47	0.152	0.0	0.212	0.212				0.127		0.250	20.49	15.1
10.47	0.166	0.0	0.217	0.217				0.141		0.555	38.45	16.4
11.47	0.185	0.0	0.216	0.216				0.142		0.319	54.74	17.4
12.47	0.200	0.0	0.218	0.218			0.0	0.140	10.700	0.133	72.63	18.0
13.47	0.197	0.0	0.216	0.216				0.143		0.092	78.45	17.9
14.47	0.191	0.000	0.213	0.214				0.135		0.052	83.85	16.8
15.47	0.179	0.001	0.210	0.212				0.136		0.034	86.46	16.2
16.47	0.167	0.001	0.211	0.212			0.0	0.142	2.600	0.036	88.56	16.1

RTI SMOG CHAMBER STUDY
USFPA CONTRACT NO. 68-02-2437

CHAMBER NO. 4
DAY 1, 10-7-77
RUN 15 (C2H5S12)

16 X SUNSHINE

TIME (EST)	OZONE (PPM)	NO (PPM)	NO2 (PPM)	NOX (PPM)	T-SUL (PPM)	SO2 (PPM)	T-P-3 (UG/M3)	PAN (PPM)	CN-5 (K-CN/CM3)	SR (L/MIN)	CU-SR (LANG) CELSIUS	TEMP (L/MIN)
0.63	0.0	0.001	0.002	0.003	0.0	0.0				0.0	0.0	14.6
1.63	0.0	0.000	0.002	0.002	0.0	0.0				0.0	0.0	12.6
2.73	0.0	0.440	0.0	0.440	0.0	0.0				0.0	0.0	12.0
3.73	0.0	0.452	0.096	0.549	1.500	0.0				0.0	0.0	12.4
4.60	0.0	0.446	0.099	0.545	1.500	0.0			1.400	0.0	0.0	11.7
5.63	0.0	0.440	0.191	0.541	1.500	0.0	6.1	0.0		0.0	0.0	10.8
6.63	0.0	0.422 ^{a/}	0.115 ^{a/}	0.538 ^{a/}	1.500	0.0		0.0		0.0	0.0	10.8
7.63	0.023	0.012 ^{a/}	0.129	0.340	0.605	0.651		0.010	23.000	0.202	9.62	12.6
8.63	0.001	0.000	0.291	0.299	0.673	0.562	161.9	0.125		0.231	30.39	14.5
9.63	0.144	0.004	0.202	0.206	0.636	0.542		0.171		0.046	64.30	16.5
10.63	0.231	0.004	0.275	0.279	0.572	0.473	43.9	0.166		0.230	113.07	18.4
11.63	0.314	0.004	0.272	0.275	0.531	0.435		0.191	25.000	0.095	172.13	19.6
12.63	0.383	0.005	0.271	0.276	0.489	0.395	53.6	0.187		0.085	231.45	20.3
13.63	0.444	0.003	0.263	0.266	0.456	0.365		0.183		0.088	286.09	20.6
14.63	0.470	0.004	0.254	0.257	0.423	0.338		0.172		0.509	325.04	20.5
15.63	0.472	0.003	0.245	0.248	0.393	0.312	27.9	0.175	2.400	0.411	352.68	20.6
16.63	0.450	0.003	0.233	0.235	0.302	0.241		0.162		0.163	367.96	19.6
17.63	0.418	0.004	0.227	0.230	0.170	0.123	10.7	0.151	0.900	0.027	372.60	17.3
18.63	0.385	0.004	0.222	0.225	0.064	0.049		0.140		0.0	373.20	15.1
19.63	0.362	0.005	0.217	0.221				0.133		0.0	373.20	14.6
20.63	0.340	0.004	0.213	0.216				0.122		0.001	373.24	13.6
21.63	0.320	0.004	0.209	0.212				0.124		0.002	373.13	13.3
22.63	0.300	0.003	0.205	0.207				0.120		0.003	373.09	12.1
23.63	0.281	0.002	0.200	0.202				0.124		0.003	373.07	13.9

a/ Data insufficient to permit correction for interference.

DAY 2, 10-8-77

29 X SUNSHINE

TIME (EST)	OZONE (PPM)	NO (PPM)	NO2 (PPM)	NOX (PPM)	T-SUL (PPM)	SO2 (PPM)	T-P-3 (UG/M3)	PAN (PPM)	CN-5 (K-CN/CM3)	SR (L/MIN)	CU-SR (LANG) CELSIUS	TEMP (L/MIN)
0.63	0.261	0.003	0.197	0.200				0.125		0.003	0.11	13.7
1.63	0.230	0.002	0.192	0.194				0.115		0.002	0.26	13.6
2.63	0.224	0.002	0.190	0.192				0.110		0.003	0.41	13.4
3.63	0.205	0.002	0.187	0.189				0.122		0.003	0.59	13.4
4.63	0.187	0.002	0.183	0.185				0.118		0.003	0.77	13.6
5.63	0.173	0.003	0.180	0.183				0.110	0.0	0.003	0.95	13.6
6.63	0.157	0.002	0.179	0.181			0.0	0.110		0.008	1.32	13.3
7.63	0.145	0.001	0.176	0.177				0.111		0.049	3.35	13.4
8.63	0.136	0.001	0.176	0.177				0.109		0.150	10.11	13.9
9.63	0.134	0.0	0.178	0.178				0.111		0.250	22.69	15.1
10.63	0.149	0.0	0.181	0.181				0.129		0.355	41.86	16.4
11.63	0.165	0.0	0.181	0.181				0.129		0.319	61.80	17.4
12.63	0.172	0.0	0.181	0.181			3.0	0.133	9.600	0.133	73.91	18.0
13.63	0.166	0.0	0.181	0.181				0.125		0.092	80.34	17.9
14.63	0.158	0.000	0.179	0.180				0.128		0.052	88.35	16.0
15.63	0.146	0.001	0.170	0.179				0.118		0.034	86.79	16.2
16.63	0.133	0.001	0.170	0.179			0.0	0.122	2.500	0.036	80.00	16.1

CHAMBER NO. 1
DAY 1, 10-10-77
RUM 36 I CH3-S-C2H6 76 R SUNSHINE
BTL SMUG CHAMBER STUDY
USEPA CONTRACT NO. 68-02-2437

TIME (EST)	OZONE (PPM)	NO (PPM)	NO2 (PPM)	NOX (PPM)	1-SUL (PPM)	SU2 (PPM)	1-P-S (UG/M3)	PAN (PPM)	CN-S (K-CN/CM3)	SR (L/MIN)	CU-SR (LANG) CELSIUS	TEMP (CELSIUS)
0.13	0.005	0.005	0.003	0.008						0.0	0.0	9.9
1.13	0.0	0.003	0.004	0.007						0.0	0.0	8.5
3.07	0.000	0.147	0.0	0.147	0.963	0.0			0.0	0.0	0.0	5.0
3.07	0.000	0.160	0.036	0.197					0.0	0.0	0.0	5.0
4.47	0.000	0.156	0.039	0.195	0.956	0.0	0.0			0.0	0.0	8.2
5.13	0.000	0.155	0.016	0.191	0.943	0.0	0.0			0.0	0.0	3.7
6.13	0.000	0.150 ^{a/}	0.039 ^{a/}	0.189 ^{a/}	1.118	0.0	0.0		23.000	0.018	0.14	3.4
6.00	0.0	0.145	0.042	0.187	1.109	0.0		0.001		0.018	0.06	3.4
7.47	0.003	0.183	0.075	0.179	1.068	0.0		0.0		0.202	0.78	6.2
8.13	0.038	0.032	0.117	0.149	0.935	0.010		0.004		0.507	17.15	10.5
9.13	0.168	0.008	0.063	0.071	0.673	0.010	75.2		31.000	0.608	48.36	12.4
10.13	0.185	0.000	0.043	0.051	0.466			0.019		0.716	65.68	13.2
11.13	0.167	0.007	0.043	0.050	0.427			0.018		0.956	130.52	14.7
12.13	0.159	0.005	0.044	0.048	0.391			0.019		0.944	187.78	14.9
13.13	0.158	0.005	0.046	0.050	0.363			0.020		0.788	243.21	15.9
14.13	0.156	0.004	0.046	0.050	0.329			0.020		0.744	290.14	16.8
15.13	0.153	0.004	0.044	0.048	0.320		24.6	0.021	12.500	0.547	335.25	17.1
16.13	0.145	0.009	0.045	0.054	0.292	0.010	0.0	0.021	2.400	0.236	363.64	16.9
17.13	0.124	0.013	0.044	0.056	0.258	0.010		0.020		0.020	376.12	14.1
18.13	0.102	0.015	0.043	0.058	0.248			0.020		0.0	377.16	11.5
19.13	0.084	0.018	0.043	0.060	0.218			0.020		0.0	377.16	10.7
20.13	0.069	0.020	0.041	0.061				0.017		0.002	377.17	11.1
21.13	0.056	0.018	0.043	0.061				0.017		0.001	377.29	10.9
22.13	0.046	0.020	0.041	0.061				0.016		0.001	377.35	10.4
23.13	0.036	0.016	0.041	0.057				0.017		0.001	377.41	9.8

^{a/} Data are insufficient to permit correction for interference.

DAY 2, 10-11-77
55 R SUNSHINE

TIME (EST)	OZONE (PPM)	NO (PPM)	NO2 (PPM)	NOX (PPM)	1-SUL (PPM)	SU2 (PPM)	1-P-S (UG/M3)	PAN (PPM)	CN-S (K-CN/CM3)	SR (L/MIN)	CU-SR (LANG) CELSIUS	TEMP (CELSIUS)
0.13	0.027	0.015	0.040	0.055				0.019		0.002	0.02	10.1
1.13	0.022	0.013	0.039	0.052				0.015		0.001	0.13	9.6
2.13	0.016	0.013	0.037	0.050				0.017		0.0	0.18	8.8
3.13	0.012	0.010	0.035	0.045						0.0	0.18	7.6
4.13	0.008	0.008	0.038	0.047						0.0	0.18	7.0
5.13	0.006	0.007	0.037	0.044			0.0	0.018		0.0	0.18	6.2
6.13	0.004	0.006	0.036	0.043			0.0	0.013		0.023	0.36	6.1
7.13	0.004	0.006	0.035	0.041				0.014		0.231	3.36	6.4
8.13	0.009	0.006	0.038	0.044				0.017		0.250	17.37	11.6
9.13	0.018	0.006	0.040	0.046	0.212	0.0		0.021		0.582	34.96	14.7
10.13	0.039	0.007	0.039	0.046	0.159	0.0		0.022		0.685	72.24	16.9
11.13	0.087	0.006	0.042	0.048	0.153	0.010		0.017		0.749	124.28	18.0
12.13	0.119	0.005	0.042	0.047	0.146	0.010	0.0	0.020	1.600	0.754	169.26	18.6
13.13	0.146	0.003	0.043	0.046	0.135	0.010		0.020		0.450	212.13	18.6
14.13	0.148	0.004	0.041	0.045	0.121	0.010		0.019		0.363	238.45	18.6
15.13	0.144	0.003	0.041	0.044	0.117	0.010		0.019		0.205	259.00	18.5
16.13	0.135	0.003	0.041	0.044	0.113	0.010		0.021		0.097	270.46	18.1
17.13		0.005	0.042	0.047			0.0	0.022	0.250	0.018	275.66	17.2

CHAMBER NO. 2
DAY 1, 10-10-77
RUN 36 I CH3-S-C2H5

76 X SUNSHINE

TIME (EST)	OZONE (PPH)	NO (PPH)	NO2 (PPH)	NOX (PPH)	T-SUL (PPH)	SU2 (PPH)	T-P-S (UG/M3)	PAN (PPH)	CN-S (K-CN/CH3)	SR (L/MIN)	CU-SR (LANG)	TEMP CELSIUS
0.30	0.0	0.003	0.003	0.006						0.0	0.0	9.9
1.30	0.0	0.001	0.006	0.007	0.975				0.0	0.0	0.0	6.5
3.27	0.000	0.078	0.0	0.078	0.977	0.0	0.0		0.0	0.0	0.0	5.0
4.30	0.000	0.000	0.022	0.102	0.977	0.0	0.0		0.0	0.0	0.0	4.2
4.43	0.000	0.000	0.022	0.102	0.962	0.0	0.0		0.0	0.0	0.0	4.2
5.30	0.000	0.079	0.023	0.102	0.954	0.0	0.0	0.0	16.000	0.0	0.0	3.7
6.30	0.000	0.076 ^{a/}	0.021 ^{a/}	0.099 ^{a/}	1.151	0.0	0.0	0.001		0.018	0.32	3.4
6.97	0.002	0.070	0.020	0.098	1.144	0.0	0.0	0.0		0.018	1.05	3.4
7.63	0.011	0.040	0.050	0.090	1.090	0.0	0.0	0.0		0.202	8.72	6.2
8.30	0.055	0.016	0.052	0.068	0.904	0.010	31.5	0.0		0.507	22.33	10.5
9.30	0.118	0.008	0.024	0.033	0.805	0.010		0.0	22.000	0.608	54.56	12.4
10.30	0.136	0.008	0.019	0.027	0.627			0.014		0.716	92.99	13.2
11.30	0.131	0.007	0.022	0.029	0.597			0.016		0.956	140.27	14.7
12.30	0.131	0.006	0.022	0.028	0.561	0.024		0.024		0.944	197.41	14.9
13.30	0.134	0.006	0.025	0.032	0.536	0.015		0.015		0.788	251.24	15.9
14.30	0.134	0.006	0.026	0.032	0.501	0.019		0.019	11.500	0.744	297.73	16.0
15.30	0.134	0.006	0.029	0.035	0.485	0.010	8.8	0.019		0.547	338.63	17.1
16.30	0.124	0.010	0.029	0.040	0.466	0.010	6.0	0.014	1.700	0.236	366.05	16.9
17.30	0.105	0.014	0.026	0.040	0.409	0.010		0.011		0.020	376.32	18.1
18.30	0.085	0.018	0.025	0.044	0.395	0.010		0.012		0.0	377.16	11.5
19.30	0.068	0.020	0.026	0.045	0.365			0.011		0.0	377.16	10.7
20.30	0.056	0.021	0.025	0.046	0.350			0.011		0.002	377.20	11.1
21.30	0.046	0.022	0.024	0.045	0.343			0.014		0.001	377.30	10.4
22.30	0.037	0.021	0.024	0.045	0.333			0.011		0.001	377.36	10.4
23.30	0.029	0.017	0.025	0.042	0.326			0.011		0.001	377.42	9.8

a/ data are insufficient to permit correction for interference.

DAY 2, 10-11-77

55 X SUNSHINE

TIME (EST)	OZONE (PPH)	NO (PPH)	NO2 (PPH)	NOX (PPH)	T-SUL (PPH)	SU2 (PPH)	T-P-S (UG/M3)	PAN (PPH)	CN-S (K-CN/CH3)	SR (L/MIN)	CU-SR (LANG)	TEMP CELSIUS
0.30	0.023	0.014	0.022	0.036	0.317			0.014		0.002	0.04	10.1
1.30	0.018	0.013	0.023	0.036	0.312			0.009		0.001	0.14	9.8
2.30	0.014	0.014	0.022	0.036	0.308			0.010		0.0	0.18	8.8
3.30	0.011	0.012	0.022	0.034						0.0	0.18	7.6
4.30	0.007	0.013	0.022	0.035	0.276					0.0	0.18	7.0
5.30	0.006	0.009	0.023	0.032	0.261					0.0	0.18	6.2
6.30	0.004	0.007	0.023	0.031	0.245		0.0	0.014	0.0	0.023	0.59	6.1
7.30	0.004	0.007	0.022	0.029	0.278			0.012		0.231	5.72	4.4
8.30	0.010	0.006	0.023	0.029	0.273			0.014		0.250	14.92	11.6
9.30	0.022	0.007	0.025	0.032	0.336	0.0		0.015		0.582	40.90	14.7
10.30	0.045	0.008	0.025	0.033	0.285	0.0		0.016		0.685	81.27	16.9
11.30	0.090	0.007	0.031	0.038	0.275	0.010		0.017		0.749	131.92	18.0
12.30	0.118	0.006	0.031	0.036	0.261		0.0	0.016	1.200	0.754	176.95	18.6
13.30	0.136	0.005	0.032	0.037	0.244	0.010		0.016		0.450	216.72	18.6
14.30	0.137	0.004	0.032	0.036	0.237	0.010		0.016		0.363	242.15	18.6
15.30	0.135	0.004	0.031	0.036	0.228	0.010		0.019		0.205	261.09	18.5
16.30	0.126	0.005	0.030	0.035	0.223	0.010	0.0	0.020	0.250	0.097	271.45	18.1
17.30								0.014		0.018	275.84	17.2

CHAMBER NO. 3
DAY 1, 10-10-77
RUN 36 1 CH3-S-C2H5 76 % SUNSHINE
RTI SMOG CHAMBER STUDY
USEPA CONTRACT NO. 68-02-2437

TIME (EST)	OZONE (PPM)	NO (PPM)	NO2 (PPM)	NOX (PPM)	T-SUL (PPM)	SU2 (PPM)	T-P-S (UG/M3)	PAN (PPM)	CN-5 (K-CN/CM3)	SR (L/MIN)	CU-SR (LANG) CELSIUS	TEMP
0.47	0.0	0.001	0.006	0.007						0.0	0.0	9.9
1.47	0.0	0.003	0.005	0.008						0.0	0.0	8.5
2.47	0.0	0.008	0.0	0.780						0.0	0.0	6.8
3.50	0.000	0.011	0.213	1.024	0.982		0.0		0.0	0.0	0.0	5.0
4.80	0.000	0.790	0.226	1.016	0.976					0.0	0.0	4.2
5.47	0.000	0.772	0.234	1.005	0.965					0.0	0.0	3.7
6.47	0.001	0.740a/	0.245a/	0.993a/	1.162			0.001	22.000	0.018	0.51	3.4
7.13	0.001	0.692	0.207	0.979	1.132			0.0		0.202	2.66	6.2
7.60	0.001	0.506	0.428	0.936	0.997			0.000		0.202	10.78	6.2
8.47	0.020	0.192	0.611	0.802	0.735			0.003		0.507	27.50	10.5
9.47	0.197	0.019	0.495	0.514	0.593		141.9	0.046		0.608	60.77	12.4
10.47	0.292	0.005	0.297	0.302				0.080	31.000	0.716	100.29	13.2
11.47	0.407	0.003	0.233	0.237				0.109		0.956	150.02	14.7
12.47	0.417	0.0	0.232	0.232				0.113		0.944	207.04	14.9
13.47	0.418	0.001	0.227	0.228				0.105		0.788	259.28	15.9
14.47	0.424	0.000	0.224	0.224				0.095		0.744	305.32	16.8
15.47	0.420	0.001	0.222	0.224			42.6	0.093	11.000	0.547	344.41	17.1
16.47	0.413	0.006	0.216	0.222	0.010		42.0	0.082	4.000	0.236	368.45	16.9
17.47	0.382	0.011	0.211	0.222	0.010			0.075		0.020	376.52	14.1
18.47	0.350	0.013	0.206	0.219	0.0			0.071		0.0	377.16	11.5
19.47	0.341	0.014	0.203	0.217				0.071		0.0	377.16	10.7
20.47	0.327	0.015	0.200	0.215				0.072		0.002	377.22	11.1
21.47	0.313	0.016	0.197	0.213				0.067		0.001	377.31	10.9
22.47	0.298	0.015	0.198	0.209				0.069		0.001	377.37	10.4
23.47	0.285	0.014	0.192	0.206				0.069		0.001	377.43	9.8

a/ data are insufficient to permit correction for interference.

DAY 2, 10-11-77
55 % SUNSHINE

TIME (EST)	OZONE (PPM)	NO (PPM)	NO2 (PPM)	NOX (PPM)	T-SUL (PPM)	SU2 (PPM)	T-P-S (UG/M3)	PAN (PPM)	CN-5 (K-CN/CM3)	SR (L/MIN)	CU-SR (LANG) CELSIUS	TEMP
0.47	0.273	0.011	0.190	0.201						0.002	0.06	10.1
1.47	0.261	0.010	0.186	0.197				0.072		0.001	0.15	9.8
2.47	0.251	0.007	0.186	0.193				0.068		0.0	0.18	8.8
3.47	0.239	0.006	0.185	0.191				0.068		0.0	0.18	7.6
4.47	0.231	0.006	0.180	0.186						0.0	0.18	7.0
5.47	0.222	0.004	0.180	0.184					0.0	0.0	0.18	6.2
6.47	0.215	0.001	0.176	0.178			0.0			0.0	0.18	6.1
7.47	0.206	0.001	0.176	0.177				0.070		0.023	0.63	6.4
8.47	0.203	0.002	0.175	0.177	0.0	0.0		0.070		0.231	22.47	11.6
9.47	0.207	0.002	0.176	0.178	0.0	0.0		0.071		0.250	22.47	11.6
10.47	0.210	0.004	0.176	0.180	0.0	0.0		0.075		0.582	46.83	14.7
11.47	0.311	0.005	0.179	0.184	0.010	0.010		0.076		0.885	90.30	16.9
12.47	0.354	0.003	0.179	0.182	0.010	0.010		0.073		0.749	139.56	18.0
13.47	0.384	0.001	0.178	0.179	0.010	0.010		0.080		0.754	184.64	18.6
14.47	0.389	0.001	0.178	0.179	0.010	0.010	0.0	0.076	1.800	0.450	221.31	18.6
15.47	0.368	0.001	0.174	0.175	0.010	0.010		0.079		0.363	245.86	18.4
16.47	0.336	0.003	0.169	0.172	0.010	0.010		0.076		0.205	263.18	18.5
17.47	0.316	0.005	0.164	0.169	0.010	0.010	0.0	0.075		0.097	272.43	18.1
								0.068	0.0	0.018	276.03	17.2

RTI SMUG CHAMBER STUDY USEPA CONTRACT NO. 68-02-2437												
CHAMBER NO. 4												
DAY 1, 10-10-77												
RUN 36 1 CH3-3-C2H5 76 X SUNSHINE												
TIME (EST)	OZONE (PPM)	H2 (PPM)	NO2 (PPM)	NOX (PPM)	I-SUL (PPM)	SO2 (PPM)	I-P-S (UG/M3)	PAH (PPM)	CN-S (K-CN/CM3)	SR (L/MIN)	CU-SR (LANG)	TEMP (CELSIUS)
0.63	0.0	0.002	0.004	0.005						0.0	0.0	9.9
1.63	0.0	0.001	0.004	0.005						0.0	0.0	8.5
2.63	0.000	0.394	0.0	0.394						0.0	0.0	6.8
3.63	0.000	0.419	0.106	0.525	0.963	0.0				0.0	0.0	5.0
4.63	0.000	0.411	0.103	0.514	0.957	0.0	0.0		0.0	0.0	0.0	4.2
5.63	0.000	0.406	0.107	0.513	0.985	0.0		0.0		0.0	0.0	3.7
6.63	0.001	0.398a/	0.109a/	0.503a/	1.142	0.0		0.0		0.010	0.00	3.4
7.63	0.001	0.340	0.152	0.492	1.099	0.0		0.0	17,500	0.202	4.72	6.2
8.63	0.007	0.177	0.270	0.447	0.956	0.010		0.000		0.507	32.36	10.5
9.63	0.076	0.080	0.316	0.356	0.979	0.010	79.2			0.608	66.00	12.4
10.63	0.265	0.008	0.171	0.179	0.356	0.054		0.038	29,000	0.716	107.16	13.2
11.63	0.270	0.004	0.119	0.122	0.243			0.062		0.956	159.20	14.7
12.63	0.268	0.001	0.119	0.120				0.060		0.944	216.10	14.9
13.63	0.263	0.001	0.116	0.117				0.059		0.788	266.45	15.9
14.63	0.260	0.003	0.116	0.118				0.054		0.744	312.46	16.8
15.63	0.260	0.002	0.116	0.118			25.3	0.051	11,500	0.547	349.46	17.1
16.63	0.244	0.008	0.112	0.120	0.010	0.010	19.9	0.040	2,800	0.236	370.72	16.9
17.63	0.216	0.012	0.100	0.120	0.010	0.0		0.043		0.020	376.72	14.1
18.63	0.190	0.013	0.106	0.119	0.010	0.0		0.042		0.0	377.16	11.5
19.63	0.179	0.015	0.106	0.121				0.040		0.002	377.23	10.7
20.63	0.165	0.015	0.105	0.120				0.040		0.001	377.32	11.1
21.63	0.151	0.016	0.104	0.120				0.040		0.001	377.38	10.9
22.63	0.137	0.018	0.102	0.116				0.040		0.001	377.50	10.9
23.63	0.125	0.013	0.103	0.116				0.038		0.001	377.44	9.9

a/ Data are insufficient to permit correction for interference.

DAY 2, 10-11-77												
55 X SUNSHINE												
TIME (EST)	OZONE (PPM)	NO (PPM)	H2O (PPM)	H2O (PPM)	I-SUL (PPM)	SO2 (PPM)	I-P-S (UG/M3)	PAH (PPM)	CN-S (K-CN/CM3)	SR (L/MIN)	CU-SR (LANG)	TEMP (CELSIUS)
0.63	0.115	0.011	0.102	0.113				0.030		0.002	0.08	10.1
1.63	0.104	0.007	0.100	0.107				0.030		0.001	0.16	9.8
2.63	0.096	0.006	0.097	0.103				0.035		0.0	0.18	8.6
3.63	0.088	0.006	0.092	0.103						0.0	0.18	7.6
4.63	0.081	0.006	0.095	0.101						0.0	0.18	7.0
5.63	0.074	0.004	0.096	0.100				0.030	0.0	0.0	0.18	6.2
6.63	0.069	0.001	0.093	0.094			0.0	0.030		0.023	1.05	6.1
7.63	0.069	0.0	0.095	0.095			0.0	0.040		0.231	10.29	6.4
8.63	0.080	0.002	0.094	0.096	0.0	0.0		0.042		0.250	24.07	11.6
9.63	0.123	0.005	0.097	0.102	0.0	0.0		0.053		0.562	52.92	14.7
10.63	0.186	0.005	0.097	0.101	0.0	0.0		0.042		0.865	96.79	16.9
11.63	0.220	0.001	0.097	0.098	0.010	0.010		0.050		0.749	146.75	18.0
12.63	0.247	0.001	0.097	0.090	0.010	0.0	0.0	0.050		0.758	191.68	18.6
13.63	0.251	0.002	0.094	0.097	0.010	0.0		0.044	2,100	0.450	225.63	18.6
14.63	0.247	0.003	0.093	0.096	0.010	0.0		0.049		0.363	240.34	18.6
15.63	0.234	0.003	0.093	0.096	0.010	0.0		0.047		0.205	265.15	18.5
16.63	0.234	0.003	0.093	0.096	0.010	0.0		0.043		0.097	271.37	18.1
17.63			0.091	0.094	0.0	0.0	0.0		0.0	0.018	276.20	17.2

RTI SMUG CHAMBER STUDY
USEPA CONTRACT NO. 68-02-2437

CHAMBER NO. 1
DAY 1, 10-15-77
RUN 17 : C2H5-S-C2H5 100 X SUNSHINE

TIME (EST)	OZONE (PPH)	NO (PPH)	NO2 (PPH)	HUX (PPH)	T-SUL (PPH)	SO2 (PPH)	T-P-S (UG/M3)	PAN (PPH)	CN-S (K-CN/CM3)	SR (L/MIN)	CU-SR (LANG)	TEMP CELSIUS
0.13	0.0	0.002	0.003	0.005	0.010	0.0				0.006	0.05	4.4
1.13	0.0	0.021	0.0	0.021	0.079	0.0				0.007	0.41	3.6
2.63	0.0	0.435	0.0	0.435	0.679	0.0				0.006	1.01	3.1
3.63	0.0	0.435	0.0	0.435	0.679	0.0				0.006	1.37	2.2
4.47	0.0	0.429	0.072	0.507	0.865	0.0	0.0			0.005	1.64	2.0
5.47	0.0	0.422	0.094	0.516	0.857	0.0			1.600	0.004	1.91	1.3
6.13	0.0	0.418	0.104	0.522	0.867	0.0	10.6			0.022	2.21	1.6
7.13	0.0	0.394	0.115	0.509	0.840	0.0				0.243	5.26	4.0
7.60	0.003	0.320	0.181	0.501	0.782	0.010				0.243	15.02	4.0
8.47	0.018	0.167	0.284	0.451	0.651	0.010			27.000	0.406	29.39	7.9
9.13	0.083	0.061	0.317	0.370	0.500	0.010	63.5			0.698	47.74	11.4
10.13	0.225	0.021	0.235	0.256	0.315	0.010				0.864	90.92	14.2
11.13	0.318	0.013	0.182	0.195	0.210	0.010			6.600	1.010	143.90	16.9
12.13	0.331	0.010	0.178	0.188	0.159	0.010	14.0			1.012	204.51	17.6
13.13	0.334	0.010	0.173	0.183	0.137	0.010				0.927	264.57	18.2
14.13	0.337	0.008	0.172	0.180	0.100	0.010				0.751	316.62	18.7
15.13	0.335	0.008	0.168	0.176	0.073	0.010				0.514	362.03	18.9
16.13	0.325	0.008	0.163	0.171	0.062	0.010			3.400	0.233	390.68	19.3
17.13	0.304	0.008	0.159	0.167	0.053	0.010	3.8			0.024	403.03	15.4
18.13	0.274	0.007	0.154	0.161					2.100	0.0	404.28	11.6
19.13	0.252	0.002	0.153	0.155						0.0	404.28	9.9
20.13	0.234	0.0	0.150	0.150						0.001	404.29	6.3
21.13	0.220	0.0	0.148	0.148						0.005	404.38	6.1
22.13	0.204	0.0	0.146	0.146						0.009	404.71	6.6
23.13	0.190	0.0	0.142	0.142						0.008	405.24	10.1

a/ Interference-corrected initial [H], [NO₂], and [NO_x] are 0.418, 0.091, and 0.509 ppm.

DAY 2, 10-16-77
17 X SUNSHINE

TIME (EST)	OZONE (PPH)	NO (PPH)	NO2 (PPH)	HUX (PPH)	T-SUL (PPH)	SO2 (PPH)	T-P-S (UG/M3)	PAN (PPH)	CN-S (K-CN/CM3)	SR (L/MIN)	CU-SR (LANG)	TEMP CELSIUS
0.13	0.174	0.0	0.142	0.142						0.007	0.05	12.4
1.13	0.159	0.0	0.141	0.141						0.005	0.46	12.1
2.13	0.144	0.0	0.140	0.140						0.004	0.75	11.8
3.13	0.130	0.0	0.140	0.140						0.003	0.98	11.3
4.13	0.110	0.0	0.136	0.136						0.004	1.17	11.2
5.13	0.107	0.0	0.135	0.135						0.004	1.41	10.6
6.13	0.095	0.001	0.134	0.135			0.0			0.024	1.64	9.8
7.13	0.084	0.004	0.134	0.134						0.090	4.00	10.4
8.13	0.079	0.003	0.131	0.134						0.159	9.94	11.0
9.13	0.075	0.003	0.130	0.134						0.164	19.52	10.9
10.13	0.074	0.004	0.133	0.137						0.101	30.43	10.8
11.13	0.076	0.004	0.132	0.135			0.0		0.250	0.109	46.99	9.3
12.13	0.074	0.005	0.131	0.136						0.353	55.43	9.0
13.13	0.077	0.003	0.129	0.132						0.502	77.78	9.4
14.13	0.084	0.004	0.132	0.137						0.220	105.70	10.1
15.13	0.080	0.004	0.126	0.129						0.358	119.62	10.6
16.13	0.084	0.006	0.126	0.131			0.0			0.195	136.90	11.3
17.13									0.0	0.028	144.76	10.2

CHAMBER NO. 2
DAY 1, 10-15-77
RUN 37 : C2H5-S-C2H5 100 X SUNSHINE
RTI SMOG CHAMBER STUDY
USEPA CONTRACT NO. 68-02-2437

TIME (EST)	OZONE (PPH)	NO (PPH)	NO2 (PPH)	NOX (PPH)	T-SUL (PPH)	SO2 (PPH)	T-P-S (UG/M3)	PAN (PPH)	CN-5 (K-CN/CM3)	SR (L/MIN)	CU-SR (LANG) CELSIUS	TEMP (CELSIUS)
0.30	0.0	0.001	0.005	0.006	0.010	0.0				0.006	0.11	4.4
1.30	0.0	0.024	0.0	0.024	0.054	0.0				0.007	0.49	3.6
2.47	0.0	0.007	0.0	0.007	0.031	0.0				0.006	0.95	3.1
3.40	0.0	0.796 a/	0.234 a/	1.030 a/	0.031	0.0				0.006	1.20	2.2
4.63	0.0	0.772	0.254	1.026	0.036	0.0	0.0			0.005	1.69	2.0
5.63	0.0	0.761	0.261	1.022	0.031	0.0				0.004	1.95	1.3
6.30	0.0	0.754	0.267	1.021	0.036	0.0			2.050	0.022	2.44	1.6
7.30	0.0	0.706	0.292	0.990	0.795	0.0	14.5			0.243	7.73	4.0
7.97	0.002	0.586	0.301	0.967	0.714	0.010				0.243	17.50	4.0
9.30	0.010	0.169	0.525	0.694	0.565	0.010			20.000	0.406	33.29	7.9
10.30	0.044	0.169	0.619	0.780	0.425	0.010	61.4	0.020		0.698	56.86	11.4
11.30	0.145	0.057	0.573	0.630	0.274	0.097		0.048		0.864	99.73	14.2
12.30	0.242	0.026	0.460	0.494	0.191	0.110		0.066	26.000	1.010	154.20	16.9
13.30	0.327	0.010	0.364	0.394	0.154	0.115	27.0	0.095		1.012	214.84	17.6
14.30	0.359	0.006	0.325	0.331	0.143	0.115		0.110		0.927	274.03	16.2
15.30	0.437	0.005	0.293	0.290	0.112	0.086		0.119		0.751	326.48	16.7
16.30	0.484	0.004	0.276	0.280	0.086	0.010		0.117		0.514	367.27	18.9
17.30	0.457	0.006	0.261	0.267	0.083	0.065		0.114	58.000	0.233	393.05	18.3
18.30	0.427	0.003	0.252	0.255	0.066	0.051		0.110		0.024	403.27	15.4
19.30	0.404	0.002	0.246	0.248			0.0	0.101	3.300	0.0	404.28	11.6
20.30	0.362	0.001	0.241	0.242				0.100		0.0	404.28	9.9
21.30	0.371	0.0	0.236	0.236				0.114		0.001	404.30	6.3
22.30	0.354	0.0	0.233	0.233				0.121		0.005	404.43	6.1
23.30	0.338	0.0	0.229	0.229				0.129		0.009	404.60	4.6
			0.228	0.228				0.133		0.008	405.32	10.1

a/ Interference-corrected initial [NO], [NO2], and [NOx] are 0.780, 0.252, and 1.032 ppm.

DAY 2, 10-16-77

TIME (EST)	OZONE (PPH)	NO (PPH)	NO2 (PPH)	NOX (PPH)	T-SUL (PPH)	SO2 (PPH)	T-P-S (UG/M3)	PAN (PPH)	CN-5 (K-CN/CM3)	SR (L/MIN)	CU-SR (LANG) CELSIUS	TEMP (CELSIUS)
0.30	0.322	0.0	0.222	0.222				0.141		0.007	0.13	12.4
1.30	0.307	0.0	0.221	0.221				0.139		0.005	0.51	12.1
2.30	0.293	0.0	0.219	0.219				0.142		0.004	0.79	11.8
3.30	0.279	0.0	0.216	0.216				0.143		0.003	1.01	11.3
4.30	0.262	0.0	0.215	0.215				0.144		0.004	1.21	11.2
5.30	0.250	0.0	0.211	0.211				0.146	0.0	0.004	1.45	10.6
6.30	0.236	0.002	0.205	0.207	0.0	0.0	2.0	0.125		0.028	2.12	9.8
7.30	0.227	0.003	0.206	0.209	0.0	0.0		0.134		0.090	4.92	10.4
8.30	0.219	0.002	0.204	0.208	0.0	0.0		0.137		0.159	11.56	11.0
9.30	0.213	0.002	0.204	0.207	0.0	0.0		0.136		0.164	21.19	10.9
10.30	0.211	0.003	0.206	0.209	0.0	0.0		0.136		0.301	33.50	10.8
11.30	0.205	0.003	0.202	0.205	0.0	0.0	2.3	0.130	0.250	0.109	48.10	9.3
12.30	0.198	0.005	0.199	0.204	0.0	0.0		0.138		0.353	59.03	9.0
13.30	0.198	0.004	0.202	0.206	0.0	0.0		0.138		0.502	62.90	9.4
14.30	0.200	0.003	0.200	0.204	0.0	0.0		0.138		0.220	107.94	10.1
15.30	0.195	0.004	0.195	0.198	0.0	0.0		0.137		0.338	123.26	10.6
16.30	0.194	0.007	0.195	0.201			2.5	0.136		0.185	140.79	11.3
17.30			0.195	0.201				0.136	0.0	0.028	149.06	10.2

RTI SMUG CHAMBER STUDY
USEPA CONTRACT NO. 60-02-2437

CHAMBER NO. 3
DAY 1, 10-15-77
RUN 37 : C2H5-S-C2H5 100 X SUNSHINE

TIME (EST)	OZONE (PPH)	NO (PPH)	NO2 (PPH)	NOX (PPH)	T-SUL (PPH)	SO2 (PPH)	T-P-S (UG/M3)	PAN (PPH)	CH-5 (K-CN/CM3)	SR (L/MIN)	CU-SR (LANG)	TEMP CELSIUS
0.47	0.0	0.004	0.005	0.009	0.010	0.0				0.006	0.17	4.4
1.47	0.0	0.025	0.0	0.025						0.007	0.56	3.6
3.03	0.0	0.008	0.0	0.008						0.006	1.15	2.2
4.30	0.0	0.008	0.015 a/	0.103 a/	0.007	0.0	0.0	0.001		0.005	1.59	2.0
5.40	0.0	0.008	0.020	0.108	0.078	0.0				0.004	1.99	1.3
6.47	0.0	0.006	0.021	0.107	0.003	0.0	11.6	0.0	2.150	0.022	2.66	1.6
7.47	0.007	0.004	0.036	0.100	0.041	0.0				0.243	10.21	4.0
8.13	0.037	0.036	0.050	0.086	0.770	0.010		0.000	16.000	0.406	21.11	7.9
9.47	0.065	0.026	0.039	0.065	0.676	0.010		0.001		0.406	37.43	7.9
10.47	0.128	0.019	0.031	0.050	0.597	0.010	24.4	0.014		0.698	61.98	11.4
11.47	0.146	0.018	0.032	0.050	0.514	0.010		0.013		0.864	108.54	14.2
12.47	0.151	0.017	0.040	0.057	0.469	0.010		0.016		1.010	164.50	16.9
13.47	0.156	0.016	0.048	0.064	0.437	0.010	0.0	0.023	3.100	1.012	225.16	17.6
14.47	0.162	0.014	0.052	0.066	0.411	0.010		0.025		0.927	283.48	18.2
15.47	0.162	0.014	0.052	0.066	0.380	0.010		0.026		0.751	334.14	18.7
16.47	0.152	0.014	0.055	0.069	0.352	0.010		0.032		0.514	372.51	18.9
17.47	0.135	0.014	0.051	0.065	0.333	0.010		0.033	9.100	0.233	395.43	18.3
18.47	0.110	0.013	0.050	0.063	0.307	0.010	0.0	0.030		0.024	403.52	15.4
19.47	0.091	0.008	0.050	0.058	0.264	0.0		0.025	2.600	0.0	404.28	11.6
20.47	0.075	0.006	0.048	0.054	0.243			0.037		0.0	404.31	9.9
21.47	0.061	0.003	0.047	0.050	0.227			0.038		0.001	404.41	8.3
22.47	0.050	0.0	0.048	0.048	0.218			0.038		0.005	404.48	8.1
23.47	0.040	0.0	0.046	0.046				0.044		0.009	404.89	8.6
			0.046					0.046		0.008	405.40	10.1

a/ Interference-corrected initial [NO], [NO₂], and [NO_x] are 0.073, 0.033, and 0.106 ppm.

DAY 2, 10-16-77

17 X SUNSHINE

TIME (EST)	OZONE (PPH)	NO (PPH)	NO2 (PPH)	NOX (PPH)	T-SUL (PPH)	SO2 (PPH)	T-P-S (UG/M3)	PAN (PPH)	CH-5 (K-CN/CM3)	SR (L/MIN)	CU-SR (LANG)	TEMP CELSIUS
0.47	0.031	0.001	0.046	0.047				0.050		0.007	0.20	12.4
1.47	0.021	0.002	0.045	0.047				0.052		0.005	0.56	12.1
2.47	0.015	0.004	0.046	0.050				0.051		0.004	0.63	11.0
3.47	0.009	0.005	0.046	0.051				0.054		0.003	1.04	11.3
4.47	0.005	0.006	0.048	0.054				0.038		0.004	1.25	11.2
5.47	0.0	0.007	0.046	0.053				0.043	0.0	0.004	1.49	10.6
6.47	0.0	0.010	0.046	0.056	0.213	0.0	0.0	0.038		0.028	2.41	9.8
7.47	0.0	0.010	0.047	0.057	0.212	0.0		0.037		0.090	5.84	10.4
8.47	0.001	0.011	0.044	0.055	0.208	0.0		0.052		0.159	13.18	11.0
9.47	0.010	0.010	0.049	0.058	0.200	0.0		0.047		0.164	22.86	10.9
10.47	0.020	0.010	0.051	0.061	0.191	0.0				0.301	36.57	10.8
11.47	0.021	0.011	0.053	0.064	0.177	0.0	0.0	0.055	0.250	0.109	49.21	9.3
12.47	0.022	0.011	0.059	0.065	0.166	0.0		0.053		0.153	62.63	9.0
13.47	0.029	0.010	0.053	0.064	0.156	0.0		0.060		0.502	88.02	9.4
14.47	0.035	0.009	0.058	0.068				0.058		0.220	110.18	10.1
15.47	0.034	0.012	0.056	0.067			0.0	0.058		0.134	126.71	10.6
16.47	0.037	0.012	0.057	0.069				0.058		0.185	142.68	11.3
17.47									0.0	0.028	149.35	10.2

RTI SMIG CHAMBER STUDY
USCFA CONTRACT NO. 68-02-2437

CHAMBER NO. 4
DAY 1, 10-15-77
RUN 37 : C2H5-S-C2H5 100 % SUNSHINE

TIME (EST)	OZONE (PPH)	NO (PPH)	NO2 (PPH)	NOX (PPH)	T-SUL (PPH)	SU2 (PPH)	T-P-3 (UG/M3)	PAN (PPH)	CN-5 (K-CN/CM3)	SR (L/MIN)	CU-SR (LANG)	TEMP CELSIUS
0.63	0.0	0.001	0.004	0.005	0.010	0.0				0.006	0.23	4.4
1.63	0.0	0.022	0.0	0.022	0.077	0.0				0.007	0.62	3.6
2.63	0.0	0.167	0.0	0.167	0.077	0.0				0.006	1.07	3.1
4.10	0.0	0.168 a/	0.040 a/	0.208 a/	0.061	0.0	0.0	0.001		0.005	1.53	2.0
5.97	0.0	0.166	0.043	0.208	0.061	0.0			4.850	0.004	2.03	1.3
6.63	0.0	0.165	0.043	0.208	0.061	0.0				0.022	2.07	1.6
7.63	0.004	0.117	0.080	0.197	0.080	0.0	10.8	0.0		0.243	12.55	4.0
8.30	0.038	0.054	0.119	0.173	0.713	0.016		0.0	17.500	0.406	25.25	7.9
8.97	0.109	0.027	0.107	0.134	0.598	0.016		0.008		0.406	41.57	7.9
9.63	0.193	0.019	0.080	0.099	0.395	0.010	25.2	0.023		0.688	68.68	11.4
10.63	0.231	0.017	0.070	0.087	0.342	0.010		0.029		0.688	116.64	14.2
11.63	0.225	0.016	0.073	0.089	0.311	0.010		0.038		1.010	174.20	16.9
12.63	0.224	0.014	0.078	0.092	0.280	0.010	0.0	0.040	4.200	1.012	234.67	17.6
13.63	0.226	0.012	0.078	0.090	0.254	0.010		0.041		0.927	292.38	18.2
14.63	0.227	0.013	0.077	0.090	0.225	0.010		0.038		0.751	341.35	18.7
15.63	0.223	0.013	0.076	0.089	0.217	0.010		0.035	3.100	0.514	377.45	18.9
16.63	0.213	0.013	0.074	0.087	0.189	0.0		0.035		0.233	397.67	18.3
17.63	0.197	0.012	0.073	0.085			0.0	0.031	1.400	0.024	403.75	15.4
18.63	0.179	0.011	0.070	0.081				0.034		0.0	404.28	11.6
19.63	0.165	0.009	0.067	0.076				0.047		0.001	404.32	8.3
20.63	0.150	0.005	0.067	0.072				0.041		0.005	404.53	6.1
21.63	0.137	0.001	0.066	0.067				0.051		0.009	404.98	6.6
22.63	0.124	0.000	0.065	0.065				0.051		0.008	405.48	10.1
23.63	0.111	0.0	0.065	0.065				0.056				

a/ Interference-corrected initial [NO], [NO₂], and [NO_x] are 0.153, 0.057, and 0.210 ppm.

DAY 2, 10-16-77

17 % SUNSHINE

TIME (EST)	OZONE (PPH)	NO (PPH)	NO2 (PPH)	NOX (PPH)	T-SUL (PPH)	SU2 (PPH)	T-P-3 (UG/M3)	PAN (PPH)	CN-5 (K-CN/CM3)	SR (L/MIN)	CU-SR (LANG)	TEMP CELSIUS
0.63	0.100	0.0	0.065	0.065	0.126	0.0		0.055		0.007	0.26	12.4
1.63	0.090	0.001	0.064	0.065	0.126	0.0		0.054		0.005	0.61	12.1
2.63	0.082	0.002	0.062	0.064	0.126	0.0		0.051		0.004	0.87	11.6
3.63	0.074	0.003	0.064	0.067	0.121	0.0		0.050		0.003	1.07	11.3
4.63	0.066	0.006	0.064	0.070	0.105	0.0		0.052		0.004	1.29	11.2
5.63	0.059	0.006	0.062	0.068	0.094	0.0		0.047	0.0	0.004	1.53	10.6
6.63	0.052	0.008	0.062	0.070	0.094	0.0		0.044		0.028	2.68	9.8
7.63	0.047	0.007	0.064	0.073	0.126	0.0		0.053		0.009	6.70	10.4
8.63	0.050	0.009	0.064	0.072	0.126	0.0		0.053		0.159	14.71	11.0
9.63	0.054	0.008	0.064	0.072	0.121	0.0		0.060		0.164	24.44	10.9
10.63	0.054	0.009	0.064	0.073	0.110	0.0		0.060		0.301	39.46	10.8
11.63	0.056	0.009	0.066	0.073	0.105	0.0	3.4	0.061	0.210	0.109	50.26	9.3
12.63	0.061	0.009	0.063	0.073	0.094	0.0		0.062		0.353	66.02	9.0
13.63	0.064	0.009	0.066	0.075				0.057		0.502	92.84	9.4
14.63	0.064	0.009	0.066	0.075				0.056		0.220	112.30	10.1
15.63	0.064	0.009	0.065	0.073				0.056		0.338	129.96	10.6
16.63	0.064	0.011	0.064	0.075			0.0	0.059	0.200	0.185	144.45	11.3
17.63								0.059		0.028	149.62	10.2

CHAMBER NO. 1
DAY 1, 10-17-77
RUN 30 : 64445

TIME (EST)	OZONE (PPM)	WD (PPH)	ND2 (PPH)	WDX (PPH)	I-SUL (PPH)	SUL2 (PPH)	I-P-S (UG/M3)	PAN (PPH)	CH-5 (K-CN/CH3)	SR (L/MIN)	CU-SR (LANG)	TEMP CELSIUS
0.13	0.0	0.002	0.001	0.003	0.0	0.0				0.0	0.0	4.6
1.13	0.0	0.001	0.001	0.002	0.0	0.0				0.0	0.0	4.2
2.13	0.0	0.157	0.0	0.157	0.924	0.0				0.0	0.0	3.2
3.13					0.922	0.0	0.0		0.0	0.0	0.0	2.2
4.13	0.0	0.154	0.042	0.200	0.921	0.0			0.0	0.0	0.0	2.2
5.13	0.0	0.155	0.042	0.197	0.909	0.0				0.0	0.0	2.1
6.13	0.0	0.152	0.042	0.194	0.906	0.0	3.0		1.500	0.014	0.11	1.8
7.13	0.0	0.149	0.042	0.191	0.900	0.0			14.000	0.222	2.57	3.7
8.13	0.002	0.135	0.051	0.186	0.886	0.0			8.600	0.503	18.08	6.7
9.13	0.010	0.101	0.077	0.178	0.843	0.010	14.1	0.0		0.749	50.18	8.1
10.13	0.026	0.062	0.093	0.155	0.766	0.010		0.0		0.940	96.61	9.1
11.13	0.055	0.032	0.090	0.122	0.710	0.010		0.0		1.047	153.45	9.9
12.13	0.088	0.017	0.067	0.084	0.637	0.010			9.100	1.058	216.75	10.3
13.13	0.115	0.009	0.042	0.051	0.554	0.010			10.000	0.967	279.52	11.7
14.13	0.124	0.005	0.022	0.027	0.498	0.066	24.1	0.003		0.785	336.12	12.4
15.13	0.100	0.004	0.014	0.018	0.468	0.078		0.004		0.534	361.26	12.7
16.13	0.078	0.004	0.014	0.018	0.441			0.002		0.245	411.05	12.4
17.13	0.060	0.004	0.012	0.017	0.407			0.002	2.100	0.024	424.03	10.0
18.13	0.047	0.004	0.012	0.016	0.361		14.7	0.006		0.0	425.28	5.6
19.13	0.039	0.003	0.012	0.016	0.329			0.001		0.0	425.28	3.5
20.13	0.033	0.003	0.012	0.015	0.294			0.002		0.0	425.28	2.2
21.13	0.027	0.003	0.013	0.017	0.296			0.007		0.0	425.28	1.0
22.13	0.024	0.004	0.012	0.016	0.265			0.005		0.001	425.29	0.3
23.13	0.020	0.003	0.012	0.016	0.276			0.003		0.002	425.35	-0.1

Consider this value to be the interference-corrected initial concentration,

DAY 2, 10-1H-77

TIME (EST)	WZV/E (PPH)	TH (PPH)	NO2 (PPH)	WUX (PPH)	1-SUL (PPH)	S02 (PPH)	T-P-S (UG/MS)	PAN (PPH)	CM-5 (K-CH/CHS)	SR (/MIN)	CU-SR (LANG)	TEMP (CELSIUS)
0.15	0.016	0.004	0.015	0.016	0.271			0.005		0.002	0.02	-0.4
1.15	0.014	0.004	0.015	0.017	0.264			0.001		0.001	0.13	-0.9
2.15	0.012	0.004	0.012	0.015	0.258			0.004		0.001	0.19	-1.1
3.15	0.009	0.002	0.012	0.014	0.255			0.005		0.0	0.24	-1.6
4.15	0.007	0.003	0.015	0.016	0.253			0.001		0.0	0.24	-1.9
5.15	0.006	0.002	0.015	0.015	0.244		0.0	0.007		0.0	0.24	-2.1
6.15	0.005	0.003	0.015	0.016	0.243			0.002		0.015	0.54	-1.9
7.15	0.004	0.003	0.012	0.015	0.241		0.0	0.006		0.0269	3.12	0.1
8.15	0.007	0.004	0.012	0.016	0.241					0.441	20.91	5.2
9.15	0.015	0.003	0.012	0.015	0.243			0.004		0.756	51.76	10.9
10.15	0.024	0.004	0.013	0.017	0.244			0.007		0.925	97.39	15.0
11.15	0.035	0.005	0.015	0.018	0.243					0.966	153.21	16.9
12.15	0.045	0.004	0.010	0.020	0.225		0.0	0.006		0.988	211.35	18.2
13.15	0.052	0.003	0.015	0.018					6.000	0.865	269.67	18.9
14.15	0.055	0.005	0.015	0.018						0.700	320.24	19.1
15.15	0.055	0.005	0.015	0.018						0.495	360.68	19.2
16.15	0.051	0.003	0.015	0.016				0.001		0.160	387.77	17.2
17.15	0.044	0.002	0.015	0.015	0.180	0.010				0.013	396.22	16.2
18.15	0.036	0.001	0.015	0.014	0.169	0.010	0.0		1.100	0.0	396.90	13.7
19.15	0.027	0.001	0.012	0.013	0.151					0.0	396.90	12.5
20.15	0.021	0.002	0.012	0.014						0.001	396.91	12.1
21.15	0.015	0.003	0.015	0.014						0.004	396.99	14.2
22.15	0.012	0.003	0.015	0.016						0.003	397.22	14.5
23.15	0.009	0.001	0.012	0.015						0.001	397.22	14.5

CHAMBER NO. 1
DAY 3, 10-19-77
RUN 36 : CHMS

79 & SUNSHINE

R11 SMUG CHAMBER STUDY
USEPA CONTRACT NO. 68-02-2437
PAGE 3

TIME (EST)	OZONE (PPH)	NO (PPH)	NO2 (PPH)	NOX (PPH)	T-SUL (PPH)	SO2 (PPH)	T-P-S (UG/M3)	PAH (PPH)	CN-5 (K-CN/CM3)	SR (L/MIN)	CU-SR (LANG)	TEMP CELSIUS
0.13	0.007	0.001	0.012	0.013						0.002	0.02	13.4
1.13	0.005	0.001	0.012	0.013						0.0	0.12	12.2
2.13	0.004	0.001	0.012	0.013						0.0	0.12	9.4
3.13	0.003	0.001	0.012	0.013						0.001	0.13	7.8
4.13	0.002	0.000	0.012	0.012						0.001	0.19	7.2
5.13	0.001	0.000	0.010	0.011						0.001	0.25	6.7
6.13	0.0	0.001	0.011	0.012					0.200	0.011	0.39	6.1
7.13	0.0	0.001	0.010	0.011						0.173	2.31	7.0
8.13	0.006	0.002	0.012	0.014						0.446	14.63	11.4
9.13	0.018	0.003	0.010	0.013	0.125	0.010				0.708	43.74	15.4
10.13	0.034	0.001	0.012	0.014	0.094	0.010				0.867	67.62	16.2
11.13	0.047	0.001	0.012	0.013	0.103	0.010				0.974	141.52	17.4
12.13	0.060	0.001	0.012	0.013	0.097	0.010			5.700	0.403	198.62	17.6
13.13	0.065	0.0	0.014	0.014	0.090	0.010				0.730	246.23	17.7
14.13	0.070	0.000	0.013	0.013	0.089	0.010				0.671	289.57	17.7
15.13	0.072	0.000	0.012	0.012	0.082	0.010				0.495	328.46	17.1
16.13	0.068	0.002	0.013	0.015	0.073	0.010			1.400	0.217	355.99	16.9

KLY:	SAFAD	NAME	UNITS	DESCRIPTION
NUMBER	ABBR.			
44201	OZONE	(PPH)		OZONE
42601	NO	(PPH)		NITROGEN OXIDE
42602	NO2	(PPH)		NITROGEN DIOXIDE
42603	NOX	(PPH)		TOTAL NITROGEN OXIDES
62101	TEMP	CELSIUS		TEMPERATURE (DRY BULB)
63301	SR	(L/MIN)		TOTAL SOLAR RADIATION
63300	CU-SR	(LANG)		CUMULATIVE TOTAL SOLAR RADIATION
42269	T-SUL	(PPH)		TOTAL SULFUR
42401	SO2	(PPH)		SULFUR DIOXIDE
12169	T-P-S	(UG/M3)		TOTAL PARTICULATE SULFUR
44301	PAH	(PPH)		PEROXYACETYL NITRATE
31114	CN-5	(K-CN/CM3)		CONDENSATION NUCLEI (PDP=5)

CHAMBER NO. 2
DAY 1, 10-17-77
RUN 36 : 4H4S

R11 SMUG CHAMBER STUDY
USEPA CONTRACT NO. 68-02-2437

98 & SUNSHINE

TIME (EST)	CO2 (PPM)	NO2 (PPM)	NOX (PPM)	T-SUL (PPM)	S02 (PPM)	T-P-S (UG/M3)	PAN (PPM)	CN-5 (K-CN/CM3)	SR (L/MIN)	CU-SR (LANG)	TEMP CELSIUS
0.30	0.001	0.002	0.004	0.0	0.0				0.0	0.0	4.6
1.30	0.001	0.002	0.003	0.0	0.0				0.0	0.0	4.2
2.30	0.0	0.002	0.003	0.922	0.0				0.0	0.0	3.2
3.30	0.0	0.002	0.003	0.927	0.0	0.0			0.0	0.0	2.2
4.30	0.0	0.002	0.003	0.916	0.0				0.0	0.0	2.2
5.30	0.0	0.002	0.003	0.912	0.0				0.0	0.0	2.1
6.30	0.001	0.002	0.003	0.907	0.0				0.014	0.25	1.6
7.30	0.007	0.002	0.003	0.895	0.0				0.222	4.84	3.7
8.30	0.007	0.002	0.003	0.885	0.0				0.503	23.21	6.7
9.30	0.027	0.002	0.003	0.875	0.0				0.749	57.62	8.1
10.30	0.067	0.002	0.003	0.865	0.0				0.940	106.20	9.1
11.30	0.112	0.002	0.003	0.855	0.0	15.2	0.0		1.047	164.53	9.9
12.30	0.107	0.002	0.003	0.845	0.0				1.058	227.54	10.3
13.30	0.086	0.002	0.003	0.835	0.0				0.967	289.39	11.7
14.30	0.073	0.002	0.003	0.825	0.0	14.8	0.001		0.785	344.13	12.4
15.30	0.063	0.002	0.003	0.815	0.0				0.534	413.55	12.4
16.30	0.054	0.002	0.003	0.805	0.0				0.245	428.27	10.0
17.30	0.044	0.002	0.003	0.795	0.0	5.5	0.0	2.100	0.024	425.28	5.6
18.30	0.034	0.002	0.003	0.785	0.0				0.0	425.28	3.5
19.30	0.026	0.002	0.003	0.775	0.0				0.0	425.28	2.2
20.30	0.024	0.002	0.003	0.765	0.0				0.0	425.30	1.0
21.30	0.020	0.002	0.003	0.755	0.0				0.001	425.30	0.3
22.30	0.017	0.002	0.003	0.745	0.0				0.002	425.37	-0.1
23.30	0.014	0.002	0.003	0.735	0.0				0.001		

a/ Consider this value to be the interference-corrected initial concentration.

92 & SUNSHINE

TIME (EST)	CO2 (PPM)	NO2 (PPM)	NOX (PPM)	T-SUL (PPM)	S02 (PPM)	T-P-S (UG/M3)	PAN (PPM)	CN-5 (K-CN/CM3)	SR (L/MIN)	CU-SR (LANG)	TEMP CELSIUS
0.30	0.012	0.005	0.012	0.356			0.002		0.002	0.04	-0.4
1.30	0.010	0.004	0.012	0.354			0.001		0.001	0.14	-0.9
2.30	0.007	0.004	0.012	0.347			0.0		0.001	0.20	-1.3
3.30	0.006	0.003	0.011	0.345			0.001		0.0	0.24	-1.6
4.30	0.005	0.004	0.012	0.342			0.0		0.0	0.24	-1.9
5.30	0.004	0.002	0.010	0.336			0.001	0.0	0.0	0.24	-2.1
6.30	0.003	0.003	0.011	0.333		0.0	0.001		0.013	0.47	-1.9
7.30	0.004	0.003	0.011	0.331			0.0		0.269	5.86	0.1
8.30	0.009	0.003	0.011	0.329					0.481	25.82	5.2
9.30	0.017	0.004	0.011	0.327					0.736	59.27	10.9
10.30	0.020	0.003	0.011	0.319			0.002		0.925	106.63	15.0
11.30	0.040	0.004	0.014	0.317					0.966	163.07	18.9
12.30	0.050	0.004	0.013	0.310		5.6	0.0		0.988	221.42	18.2
13.30	0.050	0.004	0.012	0.308				0.550	0.445	278.49	18.9
14.30	0.060	0.003	0.015	0.298					0.700	327.42	19.1
15.30	0.060	0.004	0.012	0.295	0.071				0.495	365.73	19.2
16.30	0.050	0.003	0.012	0.292	0.010				0.160	389.40	17.2
17.30	0.050	0.003	0.015	0.289	0.010	0.0			0.013	396.35	16.2
18.30	0.045	0.001	0.011	0.287	0.015			0.580	0.0	396.90	15.7
19.30	0.030	0.001	0.011	0.283					0.0	396.90	12.5
20.30	0.034	0.002	0.012						0.001	396.92	12.1
21.30	0.030	0.003	0.010						0.004	397.03	10.2
22.30	0.027	0.002	0.012						0.003	397.25	10.5
23.30	0.025	0.001	0.011						0.001	397.40	10.0

MTI SHUG CHAMBER STUDY
USEPA CONTRACT NO. 68-02-2437
PAGE 3

CHAMBER NO. 2
DAY 3, 10-19-77
RUN 38 1 CANS

TIME (EST)	UZONE (PPM)	NO (PPM)	NO2 (PPM)	NOX (PPM)	T-SUL (PPM)	SUL2 (PPM)	T-P-S (UG/M3)	PAN (PPM)	CN-S (K-CN/CH3)	SR (L/MIN)	CU-SR (LANG)	TEMP CELSIUS
0.30	0.023	0.001	0.019	0.011						0.002	0.04	13.4
1.30	0.023	0.001	0.009	0.010						0.0	0.12	12.2
2.30	0.017	0.001	0.009	0.010						0.0	0.12	9.4
3.30	0.014	0.001	0.009	0.010						0.001	0.14	7.6
4.30	0.010	0.001	0.009	0.010						0.001	0.26	7.2
5.30	0.007	0.001	0.009	0.011					0.0	0.001	0.26	6.7
6.30	0.005	0.001	0.009	0.010						0.011	0.50	6.1
7.30	0.004	0.001	0.008	0.009						0.173	4.07	7.0
8.30	0.009	0.003	0.009	0.012	0.184	0.010				0.448	19.46	11.4
9.30	0.023	0.002	0.010	0.012	0.130	0.010				0.708	50.96	15.4
10.30	0.030	0.001	0.011	0.012	0.120	0.010				0.687	96.67	16.2
11.30	0.053	0.000	0.011	0.012	0.176	0.010				0.974	151.45	17.4
12.30	0.066	0.001	0.012	0.013	0.176	0.010			3.300	0.803	206.81	17.6
13.30	0.072	0.0	0.013	0.013	0.118	0.010				0.730	253.68	17.7
14.30	0.076	0.0	0.013	0.013	0.115	0.010				0.671	296.42	17.7
15.30	0.081	0.001	0.012	0.013	0.110	0.010			0.950	0.495	333.51	17.1
16.30	0.077	0.001	0.013	0.014	0.100	0.010				0.217	358.21	16.9

KEY:	SARAD NUMBER	NAME ANION	UNITS	DESCRIPTION
	44201	UZONE	(PPM)	UZONE
	42601	NO	(PPM)	NITROGEN DIOXIDE
	42602	NO2	(PPM)	NITROGEN DIOXIDE
	42603	NOX	(PPM)	TOTAL NITROGEN OXIDES
	62101	TEMP	CELSIUS	TEMPERATURE (DRY BULB)
	63301	SR	(L/MIN)	TOTAL SOLAR RADIATION
	63300	CU-SR	(LANG)	CUMULATIVE TOTAL SOLAR RADIATION
	42269	T-SUL	(PPM)	TOTAL SULFUR
	42401	SUL2	(PPM)	SULFUR DIOXIDE
	12169	T-P-S	(UG/M3)	TOTAL PARTICULATE SULFUR
	44301	PAN	(PPM)	PEROXYACETYL NITRATE
	31110	CN-S	(K-CN/CH3)	CONDENSATION NUCLEI (PPM25)

RTI 54UG CHAMBER STUDY
US EPA CUMULATIVE NO. 68-02-2437

CHAMBER NO. 5
DAY 1, 10-17-77
RUN 30 : CHMS

98 X SUNSHINE

TIME (LST)	OZONE (PPM)	NO (PPM)	NO2 (PPM)	NOX (PPM)	T-SUL (PPM)	SO2 (PPM)	T-P-S (UG/M3)	PAN (PPM)	CN-S (K-CH/CM3)	SR (L/MIN)	CU-SR (LANG)	TEMP CELSIUS
0.47	0.002	0.001	0.002	0.004	0.0	0.0				0.0	0.0	4.6
1.47	0.002	0.001	0.002	0.003	0.0	0.0				0.0	0.0	4.2
2.47	0.0	0.001	0.0	0.001	0.0	0.0				0.0	0.0	3.2
3.40	0.0	0.001	0.0	1.002 a/	0.009	0.0	0.0		0.225	0.0	0.0	2.2
4.47	0.0	0.001	0.002	0.005	0.070	0.0				0.0	0.0	2.2
5.47	0.0	0.001	0.002	0.005	0.075	0.0				0.0	0.0	2.1
6.47	0.0	0.001	0.002	0.005	0.075	0.0				0.0	0.0	2.1
7.47	0.0	0.001	0.002	0.005	0.075	0.0				0.0	0.0	2.1
8.47	0.0	0.001	0.002	0.005	0.075	0.0				0.0	0.0	2.1
9.47	0.001	0.001	0.002	0.005	0.075	0.0				0.0	0.0	2.1
10.47	0.001	0.001	0.002	0.005	0.075	0.0				0.0	0.0	2.1
11.47	0.002	0.002	0.002	0.005	0.075	0.0				0.0	0.0	2.1
12.47	0.002	0.002	0.002	0.005	0.075	0.0				0.0	0.0	2.1
13.47	0.002	0.002	0.002	0.005	0.075	0.0				0.0	0.0	2.1
14.47	0.002	0.002	0.002	0.005	0.075	0.0				0.0	0.0	2.1
15.47	0.002	0.002	0.002	0.005	0.075	0.0				0.0	0.0	2.1
16.47	0.0	0.001	0.002	0.005	0.075	0.0				0.0	0.0	2.1
17.47	0.0	0.001	0.002	0.005	0.075	0.0				0.0	0.0	2.1
18.47	0.0	0.001	0.002	0.005	0.075	0.0				0.0	0.0	2.1
19.47	0.0	0.001	0.002	0.005	0.075	0.0				0.0	0.0	2.1
20.47	0.0	0.001	0.002	0.005	0.075	0.0				0.0	0.0	2.1
21.47	0.0	0.001	0.002	0.005	0.075	0.0				0.0	0.0	2.1
22.47	0.0	0.001	0.002	0.005	0.075	0.0				0.0	0.0	2.1
23.47	0.0	0.001	0.002	0.005	0.075	0.0				0.0	0.0	2.1

5/ Interference-corrected Initial [NO], [NO2], and [NOx] are 0.002, 0.215, and 1.017 ppm.

DAY 2, 10-18-77

92 X SUNSHINE

TIME (LST)	OZONE (PPM)	NO (PPM)	NO2 (PPM)	NOX (PPM)	T-SUL (PPM)	SO2 (PPM)	T-P-S (UG/M3)	PAN (PPM)	CN-S (K-CH/CM3)	SR (L/MIN)	CU-SR (LANG)	TEMP CELSIUS
0.47	0.0	0.000	0.209	0.677	0.476	0.0		0.002		0.002	0.06	-0.4
1.47	0.0	0.001	0.276	0.677	0.476	0.0		0.0		0.001	0.15	-0.9
2.47	0.0	0.001	0.276	0.677	0.476	0.0		0.001		0.001	0.21	-1.3
3.47	0.0	0.001	0.276	0.677	0.476	0.0		0.0		0.0	0.24	-1.6
4.47	0.0	0.001	0.276	0.677	0.476	0.0		0.001		0.0	0.24	-1.9
5.47	0.0	0.001	0.276	0.677	0.476	0.0			0.0	0.0	0.24	-2.1
6.47	0.0	0.001	0.276	0.677	0.476	0.0			0.0	0.0	0.24	-2.1
7.47	0.001	0.001	0.276	0.677	0.476	0.0			0.0	0.0	0.24	-2.1
8.47	0.001	0.001	0.276	0.677	0.476	0.0			0.0	0.0	0.24	-2.1
9.47	0.001	0.001	0.276	0.677	0.476	0.0			0.0	0.0	0.24	-2.1
10.47	0.001	0.001	0.276	0.677	0.476	0.0			0.0	0.0	0.24	-2.1
11.47	0.001	0.001	0.276	0.677	0.476	0.0			0.0	0.0	0.24	-2.1
12.47	0.001	0.001	0.276	0.677	0.476	0.0			0.0	0.0	0.24	-2.1
13.47	0.001	0.001	0.276	0.677	0.476	0.0			0.0	0.0	0.24	-2.1
14.47	0.001	0.001	0.276	0.677	0.476	0.0			0.0	0.0	0.24	-2.1
15.47	0.001	0.001	0.276	0.677	0.476	0.0			0.0	0.0	0.24	-2.1
16.47	0.001	0.001	0.276	0.677	0.476	0.0			0.0	0.0	0.24	-2.1
17.47	0.0	0.001	0.276	0.677	0.476	0.0			0.0	0.0	0.24	-2.1
18.47	0.0	0.001	0.276	0.677	0.476	0.0			0.0	0.0	0.24	-2.1
19.47	0.0	0.001	0.276	0.677	0.476	0.0			0.0	0.0	0.24	-2.1
20.47	0.0	0.001	0.276	0.677	0.476	0.0			0.0	0.0	0.24	-2.1
21.47	0.0	0.001	0.276	0.677	0.476	0.0			0.0	0.0	0.24	-2.1
22.47	0.0	0.001	0.276	0.677	0.476	0.0			0.0	0.0	0.24	-2.1
23.47	0.0	0.001	0.276	0.677	0.476	0.0			0.0	0.0	0.24	-2.1

CHAMBER NO. 3
DAY 3, 10-19-77
RUN SW 1 C4115

TIME (H:MIN)	O ₂ IN (PPM)	IN (PPM)	NO ₂ (PPM)	NO _x (PPM)	1-3UL (PPM)	302 (PPM)	1-P-3 (UG/M3)	PAH (PPM)	CH-5 (K-CH/CM3)	3R (L/MIN)	CU-SR (L/ANG)	TEMP Celsius
0:47	0.0	0.207	0.211	0.418	0.281					0.002	0.00	13.4
1:47	0.0	0.207	0.204	0.416	0.232					0.0	0.12	12.2
2:47	0.0	0.202	0.202	0.408	0.216					0.0	0.12	9.4
3:47	0.0	0.203	0.196	0.359						0.001	0.15	7.0
4:47	0.0	0.201	0.194	0.356						0.001	0.21	7.2
5:47	0.0	0.202	0.189	0.351						0.001	0.27	6.7
6:47	0.0	0.200	0.186	0.366					35.000	0.011	0.01	6.1
7:47	0.002	0.194	0.191	0.375						0.173	5.04	7.0
8:47	0.005	0.179	0.160	0.387						0.448	23.97	11.4
9:47	0.009	0.157	0.160	0.317	0.109	0.010				0.708	58.19	15.4
10:47	0.013	0.134	0.162	0.296	0.201	0.010				0.667	195.71	16.2
11:47	0.016	0.117	0.162	0.280	0.202	0.010				0.974	161.59	17.4
12:47	0.010	0.095	0.173	0.268	0.187	0.010			2.100	0.603	215.60	17.6
13:47	0.014	0.092	0.163	0.254	0.199	0.010				0.730	261.13	17.7
14:47	0.019	0.085	0.159	0.248	0.197	0.010				0.671	393.66	17.7
15:47	0.015	0.079	0.158	0.237	0.186	0.010				0.495	338.56	17.1
16:47	0.017	0.071	0.159	0.210	0.177	0.053			1.600	0.217	360.42	16.9

NAME NUMBER	NAME ANAL.	UNITS	DESCRIPTION
00201	UO ₂ H ₂	(PPM)	UO ₂
02601	H ₂	(PPM)	NITROGEN DIOXIDE
02602	UO ₂	(PPM)	NITROGEN DIOXIDE
02603	H ₂	(PPM)	TOTAL NITROGEN DIOXIDE
02101	H ₂	CELLS/US	TEMPERATURE (CRY MUX)
03301	SW	(L/MIN)	TOTAL SOLAR RADIATION
03300	CU-SH	(LANG)	CUMULATIVE TOTAL SOLAR RADIATION
02209	1-310L	(PPM)	TOTAL SULFUR
02001	SO ₂	(PPM)	SULFUR DIOXIDE
12169	1-P-S	(UG/M3)	TOTAL PARTICULATE SULFUR
04501	PAN	(PPM)	PERFORMACEYVE MITRAT
03114	CN-5	(K-CN/CM3)	CONDENSATION NUCLEI (PDP-5)

RTI 3000, CHAMBER STUDY
USEPA CUMULATIVE NO. 08-02-2037

CHAMBER NO. 3
DAY 1, 10-11-77
RUN 30 3 CH043

90 % SUNSHINE

TIME (EST)	UZONE (PPM)	NO (PPM)	NO2 (PPM)	NO3 (PPM)	I-SUL (PPM)	SUL2 (PPM)	I-P-S (UG/M3)	PAN (PPM)	CH-5 (K-CH/CM3)	SR (L/MIN)	CU-SR (LANG)	TEMP CELSIUS
0.03	0.0	0.001	0.002	0.002	0.0	0.0				0.0	0.0	0.0
1.03	0.0	0.0	0.002	0.002	0.0	0.0				0.0	0.0	0.0
2.03	0.0	0.001	0.002	0.002	0.0	0.0				0.0	0.0	0.0
3.03	0.0	0.001	0.002	0.002	0.0	0.0				0.0	0.0	0.0
4.03	0.0	0.001	0.002	0.002	0.0	0.0				0.0	0.0	0.0
5.03	0.0	0.001	0.002	0.002	0.0	0.0				0.0	0.0	0.0
6.03	0.0	0.001	0.002	0.002	0.0	0.0				0.0	0.0	0.0
7.03	0.0	0.001	0.002	0.002	0.0	0.0				0.0	0.0	0.0
8.03	0.002	0.001	0.002	0.002	0.0	0.0				0.0	0.0	0.0
9.03	0.002	0.001	0.002	0.002	0.0	0.0				0.0	0.0	0.0
10.03	0.005	0.001	0.002	0.002	0.0	0.0				0.0	0.0	0.0
11.03	0.008	0.001	0.002	0.002	0.0	0.0				0.0	0.0	0.0
12.03	0.013	0.001	0.002	0.002	0.0	0.0				0.0	0.0	0.0
13.03	0.016	0.001	0.002	0.002	0.0	0.0				0.0	0.0	0.0
14.03	0.017	0.001	0.002	0.002	0.0	0.0				0.0	0.0	0.0
15.03	0.015	0.001	0.002	0.002	0.0	0.0				0.0	0.0	0.0
16.03	0.005	0.001	0.002	0.002	0.0	0.0				0.0	0.0	0.0
17.03	0.0	0.001	0.002	0.002	0.0	0.0				0.0	0.0	0.0
18.03	0.0	0.001	0.002	0.002	0.0	0.0				0.0	0.0	0.0
19.03	0.0	0.001	0.002	0.002	0.0	0.0				0.0	0.0	0.0
20.03	0.0	0.001	0.002	0.002	0.0	0.0				0.0	0.0	0.0
21.03	0.0	0.001	0.002	0.002	0.0	0.0				0.0	0.0	0.0
22.03	0.0	0.001	0.002	0.002	0.0	0.0				0.0	0.0	0.0
23.03	0.0	0.001	0.002	0.002	0.0	0.0				0.0	0.0	0.0

a/ Consider this value to be the interference-corrected initial concentration.

92 % SUNSHINE

TIME (EST)	UZONE (PPM)	NO (PPM)	NO2 (PPM)	NO3 (PPM)	I-SUL (PPM)	SUL2 (PPM)	I-P-S (UG/M3)	PAN (PPM)	CH-5 (K-CH/CM3)	SR (L/MIN)	CU-SR (LANG)	TEMP CELSIUS
0.03	0.0	0.002	0.002	0.002	0.0	0.0				0.002	0.0	-0.4
1.03	0.0	0.001	0.002	0.002	0.0	0.0				0.001	0.16	-0.9
2.03	0.0	0.001	0.002	0.002	0.0	0.0				0.001	0.22	-1.3
3.03	0.0	0.001	0.002	0.002	0.0	0.0				0.0	0.24	-1.6
4.03	0.0	0.001	0.002	0.002	0.0	0.0				0.0	0.24	-1.9
5.03	0.0	0.001	0.002	0.002	0.0	0.0				0.0	0.24	-2.1
6.03	0.0	0.001	0.002	0.002	0.0	0.0				0.0	0.24	-1.9
7.03	0.007	0.001	0.002	0.002	0.0	0.0				0.013	0.73	0.1
8.03	0.012	0.001	0.002	0.002	0.0	0.0				0.024	11.19	5.2
9.03	0.021	0.001	0.002	0.002	0.0	0.0				0.041	35.34	10.9
10.03	0.033	0.001	0.002	0.002	0.0	0.0				0.076	73.84	15.0
11.03	0.050	0.001	0.002	0.002	0.0	0.0				0.095	125.14	16.9
12.03	0.066	0.001	0.002	0.002	0.0	0.0				0.066	182.19	16.2
13.03	0.077	0.001	0.002	0.002	0.0	0.0				0.065	200.99	18.2
14.03	0.083	0.001	0.002	0.002	0.0	0.0				0.065	295.62	19.1
15.03	0.081	0.001	0.002	0.002	0.0	0.0				0.065	341.28	19.2
16.03	0.069	0.001	0.002	0.002	0.0	0.0				0.065	375.53	17.2
17.03	0.053	0.001	0.002	0.002	0.0	0.0				0.065	392.57	16.2
18.03	0.041	0.001	0.002	0.002	0.0	0.0				0.065	396.61	13.7
19.03	0.035	0.001	0.002	0.002	0.0	0.0				0.065	396.90	12.5
20.03	0.025	0.001	0.002	0.002	0.0	0.0				0.065	396.90	12.1
21.03	0.019	0.001	0.002	0.002	0.0	0.0				0.065	397.11	14.2
22.03	0.016	0.001	0.002	0.002	0.0	0.0				0.065	397.31	14.5
23.03	0.013	0.001	0.002	0.002	0.0	0.0				0.065	397.42	14.0

RTI SMOG CHAMBER STUDY
USEPA CONTRACT NO. 68-02-2437
PAGE 3

CHAMBER NO. 9
DAY 3, 10-19-77
RUN 38 : C4H4S

79 % SUNSHINE

TIME (EST)	OZONE (PPH)	NO (PPH)	NO2 (PPH)	NOX (PPH)	T-SUL (PPH)	SO2 (PPH)	T-P-S (UG/M3)	PAN (PPH)	CH-5 (K-CN/CM3)	SR (L/MIN)	CU-SR (LANG)	TEMP CELSIUS
0.63	0.010	0.001	0.046	0.047						0.002	0.08	13.4
1.63	0.007	0.002	0.044	0.046						0.0	0.12	12.2
2.63	0.006	0.002	0.042	0.044						0.0	0.12	9.4
3.63	0.004	0.001	0.041	0.042						0.001	0.16	7.6
4.63	0.003	0.001	0.041	0.043						0.001	0.22	7.2
5.63	0.002	0.002	0.040	0.042						0.001	0.28	6.7
6.63	0.002	0.003	0.037	0.040					1.600	0.011	0.72	6.1
7.63	0.011	0.008	0.030	0.038						0.173	7.50	7.0
8.63	0.030	0.004	0.027	0.035						0.448	28.27	11.4
9.63	0.063	0.004	0.024	0.028	0.143					0.708	64.90	15.4
10.63	0.086	0.002	0.021	0.023	0.140					0.897	114.23	16.2
11.63	0.103	0.0	0.020	0.020	0.141					0.974	170.74	17.4
12.63	0.109	0.000	0.020	0.020	0.134				15.000	0.803	222.71	17.6
13.63	0.112	0.0	0.020	0.020	0.127					0.730	268.13	17.7
14.63	0.116	0.001	0.020	0.020	0.119					0.671	309.70	17.7
15.63	0.114	0.001	0.019	0.020	0.110					0.495	343.31	17.1
16.63	0.108	0.002	0.018	0.020	0.100					0.217	362.50	16.9

KEY	SAMPLAD NUMBER	NAME ANAL.	UNITS	DESCRIPTION
	44201	OZONE	(PPH)	OZONE
	42601	NO	(PPH)	NITROGEN OXIDE
	42602	NO2	(PPH)	NITROGEN DIOXIDE
	42603	NOX	(PPH)	TOTAL NITROGEN OXIDES
	62101	TEMP	CELSIUS	TEMPERATURE (DRY BULB)
	63301	SR	(L/MIN)	TOTAL SOLAR RADIATION
	63300	CU-SR	(LANG)	CUMULATIVE TOTAL SOLAR RADIATION
	42269	T-SUL	(PPH)	TOTAL SULFUR
	42401	SO2	(PPH)	SULFUR DIOXIDE
	12169	T-P-S	(UG/M3)	TOTAL PARTICULATE SULFUR
	44301	PAN	(PPH)	PEROXYACETYL NITRATE
	31114	CH-5	(K-CN/CM3)	CONDENSATION NUCLEI (POP=5)

RTI SMUG CHAMBER STUDY
USEPA CONTRACT NO. 68-02-2437

CHAMBER NO. 1
DAY 1, 10-20-77
RUN 19 1 (CH3)2CH2S 100 % SUNSHINE

TIME (EST)	OZONE (PPH)	NO (PPH)	NO2 (PPH)	NOX (PPH)	I-SUL (PPH)	SO2 (PPH)	I-P-S (UG/M3)	PAN (PPH)	CH-5 (K-CH/CM3)	SR (L/MIN)	CU-SR (LANG)	TEMP CELSIUS
0.13	0.0	0.001	0.0	0.003	0.0	0.0				0.0	0.0	2.9
1.13	0.0	0.002	0.0	0.002	0.0	0.0				0.0	0.0	2.3
2.07	0.0	0.002	0.0	0.002	0.0	0.0				0.0	0.0	1.7
3.07	0.0	0.002	0.0	0.002	0.0	0.0				0.0	0.0	1.3
4.07	0.0	0.002	0.0	0.002	0.0	0.0				0.0	0.0	0.9
5.13	0.0	0.002	0.0	0.002	0.0	0.0	0.0		2.950	0.0	0.0	0.7
6.13	0.0	0.002	0.0	0.002	0.0	0.0	0.0		1.400	0.0	0.0	0.8
7.13	0.0	0.002	0.0	0.002	0.0	0.0	0.0		6.600	0.0	0.0	2.7
8.13	0.003	0.001	0.001	0.001	0.0	0.0	0.0			0.0	0.0	7.9
9.13	0.010	0.001	0.001	0.001	0.0	0.0	0.0			0.0	0.0	13.0
10.13	0.043	0.001	0.001	0.001	0.0	0.0	5.7		10.500	0.0	0.0	15.2
11.13	0.106	0.001	0.001	0.001	0.0	0.0	0.0			0.0	0.0	16.6
12.13	0.092	0.001	0.001	0.001	0.0	0.0	0.0			0.0	0.0	17.0
13.13	0.075	0.001	0.001	0.001	0.0	0.0	0.0			0.0	0.0	17.7
14.13	0.066	0.001	0.001	0.001	0.0	0.0	0.0			0.0	0.0	18.2
15.13	0.061	0.001	0.001	0.001	0.0	0.0	0.0			0.0	0.0	18.1
16.13	0.050	0.001	0.001	0.001	0.0	0.0	0.0			0.0	0.0	17.5
17.13	0.040	0.001	0.001	0.001	0.0	0.0	0.0			0.0	0.0	13.7
18.13	0.030	0.001	0.001	0.001	0.0	0.0	0.0			0.0	0.0	10.0
19.13	0.022	0.001	0.001	0.001	0.0	0.0	0.0			0.0	0.0	7.9
20.13	0.016	0.001	0.001	0.001	0.0	0.0	0.0			0.0	0.0	6.4
21.13	0.011	0.001	0.001	0.001	0.0	0.0	0.0			0.0	0.0	5.4
22.13	0.006	0.001	0.001	0.001	0.0	0.0	0.0			0.0	0.0	4.4
23.13	0.005	0.001	0.001	0.001	0.0	0.0	0.0			0.0	0.0	3.6

a/ Data insufficient to permit correction for interference.

b/ Interference-corrected initial [NO₂] is 0.048 ppm.

DAY 1, 10-21-77

85 % SUNSHINE

TIME (EST)	OZONE (PPH)	NO (PPH)	NO2 (PPH)	NOX (PPH)	I-SUL (PPH)	SO2 (PPH)	I-P-S (UG/M3)	PAN (PPH)	CH-5 (K-CH/CM3)	SR (L/MIN)	CU-SR (LANG)	TEMP CELSIUS
0.13	0.002	0.014	0.031	0.044	0.150	0.0				0.0	0.0	2.9
1.13	0.001	0.012	0.031	0.043	0.146	0.0				0.0	0.0	2.1
2.13	0.001	0.012	0.030	0.042	0.154	0.0				0.0	0.0	1.6
3.13	0.001	0.012	0.030	0.042	0.171	0.0				0.0	0.0	0.9
4.13	0.0	0.011	0.029	0.041	0.191	0.0				0.0	0.0	0.5
5.13	0.0	0.011	0.030	0.041	0.199	0.0				0.0	0.0	0.0
6.13	0.0	0.011	0.031	0.041	0.196	0.0	0.0		0.200	0.0	0.0	-0.2
7.13	0.0	0.011	0.030	0.041	0.146	0.0	0.0			0.0	0.0	1.7
8.13	0.004	0.013	0.030	0.043	0.154	0.0				0.0	0.0	0.5
9.13	0.007	0.012	0.030	0.042	0.171	0.0				0.0	0.0	11.4
10.13	0.012	0.011	0.031	0.042	0.191	0.0				0.0	0.0	15.3
11.13	0.025	0.011	0.031	0.042	0.199	0.0				0.0	0.0	16.5
12.13	0.036	0.010	0.029	0.039	0.196	0.0				0.0	0.0	12.2
13.13	0.040	0.008	0.026	0.036	0.215	0.0	0.0		5.000	0.0	0.0	1.7
14.13	0.045	0.006	0.026	0.032	0.204	0.0	0.0		5.700	0.0	0.0	16.2
15.13	0.048	0.006	0.025	0.031	0.203	0.0	0.0		2.400	0.0	0.0	16.5
16.13	0.045	0.005	0.025	0.030	0.193	0.0	0.0			0.0	0.0	17.6

NTI SMUG CHAMBER STUDY
USEPA CONTRACT NO. 68-02-2437

CHAMBER NO. 2
DAY 1, 10-20-77
RUN 39 1 (CH3)2C4H25 100 X SUNSHINE

TIME (EST)	UZONE (PPH)	NO (PPH)	NO2 (PPH)	NOX (PPH)	I-SUL (PPH)	SO2 (PPH)	I-P-S (UG/M3)	PAN (PPM)	CN-S (K-CN/CH3)	SH (L/MIN)	CU-SH (LANG)	TEMP CELSIUS
0.30	0.0	0.007	0.001	0.008	0.0	0.0				0.0	0.0	2.9
1.30	0.0	0.005	0.0	0.005	0.0	0.0				0.0	0.0	2.3
2.30	0.0				0.0	0.0				0.0	0.0	1.7
3.30	0.0	0.075	0.0	0.075	0.736	0.0				0.0	0.0	1.3
4.30	0.0	0.001a/	0.019b/	0.100a/	0.003	0.0			0.200	0.0	0.0	0.9
5.30	0.0	0.003	0.019	0.101	0.795	0.0				0.0	0.0	0.7
6.30	0.0	0.000	0.017	0.097	0.799	0.0			1.600	0.011	0.20	0.0
7.30	0.0	0.078	0.016	0.094	0.795	0.0				0.184	3.97	2.7
8.30	0.006	0.063	0.026	0.090	0.762	0.010				0.442	19.66	7.9
9.30	0.020	0.038	0.037	0.075	0.760	0.010			4.000	0.701	56.84	13.0
10.30	0.065	0.016	0.034	0.050	0.764	0.115	2.7			0.875	96.03	15.2
11.30	0.074	0.011	0.027	0.038	0.724	0.114	3.3			0.972	150.28	16.6
12.30	0.068	0.012	0.027	0.039	0.696	0.135			5.700	0.962	208.78	17.0
13.30	0.062	0.013	0.025	0.038	0.601	0.162		0.012	5.700	0.874	265.75	17.7
14.30	0.058	0.011	0.023	0.034	0.672	0.185	2.8			0.709	315.22	18.2
15.30	0.053	0.011	0.022	0.032	0.650	0.191	0.0	0.011	4.800	0.422	353.50	18.1
16.30	0.046	0.012	0.021	0.031	0.629	0.192		0.010	1.300	0.197	376.87	17.5
17.30	0.038	0.014	0.019	0.033	0.593	0.174	0.0	0.009		0.013	385.37	17.7
18.30	0.030	0.013	0.018	0.032	0.504	0.105		0.012		0.0	385.92	16.0
19.30	0.023	0.013	0.017	0.030	0.434	0.010		0.011		0.0	385.92	7.9
20.30	0.018	0.013	0.015	0.028	0.395	0.010		0.011		0.0	385.92	6.4
21.30	0.015	0.015	0.017	0.031	0.365	0.010		0.011		0.0	385.92	5.4
22.30	0.009	0.015	0.017	0.032	0.343	0.010		0.011		0.0	385.92	4.4
23.30	0.006	0.015	0.016	0.031	0.266	0.012		0.011		0.0	385.92	3.6

a/ Data insufficient to permit correction for interference.
b/ Interference-corrected Initial [NO2] is 0.035 ppm.

DAY 2, 10-21-77

05-X SUNSHINE

TIME (EST)	UZONE (PPH)	NO (PPH)	NO2 (PPH)	NOX (PPH)	I-SUL (PPH)	SO2 (PPH)	I-P-S (UG/M3)	PAN (PPM)	CN-S (K-CN/CH3)	SH (L/MIN)	CU-SH (LANG)	TEMP CELSIUS
0.30	0.004	0.016	0.015	0.031	0.319	0.0				0.0	0.0	2.9
1.30	0.004	0.015	0.015	0.030	0.306	0.0				0.0	0.0	2.4
2.30	0.001	0.014	0.016	0.030	0.290	0.0				0.0	0.0	1.6
3.30	0.001	0.014	0.015	0.029	0.294	0.0				0.0	0.0	0.9
4.30	0.0	0.013	0.015	0.029	0.289	0.0				0.0	0.0	0.5
5.30	0.0	0.012	0.016	0.028	0.281	0.0			0.200	0.0	0.0	0.0
6.30	0.0	0.014	0.015	0.029	0.293	0.0				0.010	0.16	-0.2
7.30	0.0	0.014	0.016	0.029	0.291	0.0	0.0			0.170	3.68	1.7
8.30	0.006	0.014	0.016	0.030	0.300	0.010				0.810	18.18	6.5
9.30	0.009	0.014	0.017	0.031	0.310	0.010				0.692	47.66	11.4
10.30	0.014	0.012	0.020	0.032	0.325	0.010				0.901	93.18	15.3
11.30	0.027	0.012	0.020	0.032	0.319	0.010				0.920	187.54	16.5
12.30	0.036	0.010	0.019	0.029	0.315	0.066			3.400	0.011	199.21	17.2
13.30	0.039	0.010	0.018	0.028	0.327	0.063				0.010	242.68	17.7
14.30	0.042	0.008	0.017	0.025	0.321	0.098	0.0			0.010	284.93	18.2
15.30	0.042	0.007	0.017	0.024	0.318	0.109				0.009	320.29	18.5
16.30	0.039	0.007	0.015	0.022	0.307	0.112	0.0			0.009	340.08	17.6

RTI SMUG CHAMBER STUDY
USEPA CONTRACT NO. 68-02-2457

CHAMBER NO. 3
DAY 1, 10-20-77
RUN 39 : (CH3)2CH2S 100 X SUNSHINE

TIME (EST)	OZONE (PPH)	NO (PPH)	NO2 (PPH)	NOX (PPH)	T-SUL (PPH)	SO2 (PPH)	T-P-S (UG/M3)	PAN (PPM)	CN-5 (K-CN/CH3)	SR (L/MIN)	CU-SR (LANG)	TEMP (CELSIUS)
0.47	0.0	0.009	0.001	0.010	0.0	0.0				0.0	0.0	2.9
1.47	0.0	0.006	0.0	0.006	0.0	0.0				0.0	0.0	2.3
2.47	0.0	0.787	0.0	0.787	0.0	0.0				0.0	0.0	1.7
3.50	0.0	0.831	0.147	0.978	0.0	0.0				0.0	0.0	1.3
3.47	0.0	0.868	0.197	1.065	0.825	0.0				0.0	0.0	1.3
4.80	0.0	0.843	0.216	1.060	0.867	0.0				0.0	0.0	0.9
5.47	0.0	0.829	0.221	1.051	0.856	0.0	0.0		0.225	0.0	0.0	0.7
6.47	0.0	0.802	0.230	1.032	0.864	0.0			26.000	0.11	0.31	0.8
7.47	0.0	0.775	0.248	1.023	0.850	0.0	0.0			0.184	5.85	2.7
8.47	0.0	0.710	0.274	0.989	0.813	0.010				0.442	24.16	7.9
9.47	0.001	0.590	0.344	0.934	0.728	0.010			29.000	0.701	57.99	13.0
10.47	0.004	0.305	0.465	0.850	0.662	0.108	27.4	0.009		0.875	104.95	15.2
11.47	0.020	0.020	0.535	0.741	0.579	0.263		0.019		0.972	160.19	16.6
12.47	0.055	0.098	0.533	0.631	0.549	0.347	34.8	0.028	31.000	0.982	218.79	17.0
13.47	0.097	0.087	0.492	0.539	0.588	0.401		0.035	29.000	0.874	274.67	17.7
14.47	0.121	0.027	0.434	0.461	0.559	0.444		0.036		0.709	322.45	18.2
15.47	0.144	0.017	0.380	0.397	0.544	0.434	23.7		27.000	0.472	350.31	18.1
16.47	0.121	0.013	0.332	0.345	0.521	0.415	0.0		1.050	0.197	378.67	17.5
17.47	0.079	0.011	0.278	0.288	0.464	0.368				0.013	385.51	13.7
18.47	0.048	0.009	0.236	0.245	0.386	0.261		0.040		0.0	385.92	10.0
19.47	0.031	0.008	0.213	0.222	0.257	0.182		0.042		0.0	385.92	7.9
20.47	0.019	0.009	0.202	0.211	0.211	0.145		0.041		0.0	385.92	6.4
21.47	0.012	0.010	0.197	0.206	0.206			0.039		0.0	385.92	5.4
22.47	0.008	0.011	0.192	0.203	0.203					0.0	385.92	4.4
23.47	0.005	0.010	0.189	0.199	0.208					0.0	385.92	3.6

a/ Interference-corrected initial [NO] is 0.830 ppm.

b/ Data insufficient to permit correction for interference.

DAY 2, 10-21-77

AS X SUNSHINE

TIME (EST)	OZONE (PPH)	NO (PPH)	NO2 (PPH)	NOX (PPH)	T-SUL (PPH)	SO2 (PPH)	T-P-S (UG/M3)	PAN (PPM)	CN-5 (K-CN/CH3)	SR (L/MIN)	CU-SR (LANG)	TEMP (CELSIUS)
0.47	0.002	0.011	0.186	0.197	0.010	0.010				0.0	0.0	2.9
1.47	0.002	0.010	0.183	0.193	0.010	0.010				0.0	0.0	2.1
2.47	0.001	0.009	0.181	0.191	0.010	0.010		0.038		0.0	0.0	1.6
3.47	0.001	0.010	0.179	0.189	0.010	0.010		0.040		0.0	0.0	0.9
4.47	0.0	0.010	0.177	0.186	0.010	0.010		0.041		0.0	0.0	0.5
5.47	0.0	0.009	0.175	0.184	0.010	0.010			0.0	0.0	0.0	0.0
6.47	0.0	0.012	0.169	0.181	0.010	0.010	0.0	0.040		0.010	0.28	-0.2
7.47	0.009	0.024	0.153	0.177	0.010	0.010		0.042		0.170	5.39	1.7
8.47	0.023	0.023	0.142	0.165	0.010	0.010				0.410	22.36	6.5
9.47	0.056	0.016	0.134	0.149	0.006	0.010		0.041		0.692	58.91	11.4
10.47	0.114	0.011	0.121	0.132	0.124	0.010		0.041		0.901	102.33	15.3
11.47	0.209	0.008	0.110	0.118	0.144	0.010		0.041	2.100	0.920	156.92	16.5
12.47	0.254	0.006	0.101	0.108	0.166	0.102		0.040		0.725	206.62	17.2
13.47	0.268	0.005	0.097	0.102	0.171	0.112	3.6	0.039	2.400	0.722	250.04	17.7
14.47	0.278	0.004	0.092	0.095	0.175	0.117		0.036		0.663	291.70	18.2
15.47	0.281	0.004	0.089	0.093	0.177	0.120	2.8	0.033		0.417	324.54	18.5
16.47	0.268	0.003	0.084	0.088	0.173	0.119		0.031	1.000	0.149	342.00	17.6
17.60										0.010	346.74	13.8

RTI SMUG CHAMBER STUDY
USEPA CONTRACT NO. 66-02-2437

CHAMBER NO. 4
DAY 1, 10-20-77
RUN 39 (CH3)2L4H2S 100 % SUNSHINE

TIME (EST)	OZONE (PPH)	NO (PPH)	NO2 (PPH)	NOX (PPH)	I-SUL (PPH)	SU2 (PPH)	I-P-S (UG/M3)	PAN (PPH)	CH-5 (K-CN/CH3)	SR (L/MIN)	CU-SR (LANG) CELSIUS	TEMP (L/MIN)
0.63	0.0	0.005	0.0	0.005	0.0	0.0				0.0	0.0	2.9
1.63	0.0	0.003	0.0	0.003	0.0	0.0				0.0	0.0	2.3
2.70	0.0	0.364	0.0	0.364	0.0	0.0				0.0	0.0	1.7
3.57	0.0	0.368	0.027	0.415	0.776	0.0				0.0	0.0	1.3
3.77	0.0	0.416a/	0.103 b/	0.519 b/	0.781	0.0				0.0	0.0	1.3
4.97	0.0	0.415	0.105	0.515	0.813	0.0				0.0	0.0	0.9
5.63	0.0	0.407	0.103	0.510	0.811	0.0	0.0		0.225	0.0	0.0	0.7
6.63	0.0	0.397	0.103	0.500	0.818	0.0				0.011	0.42	0.8
7.63	0.0	0.382	0.114	0.495	0.803	0.0	0.0		17.000	0.184	7.62	2.7
8.63	0.001	0.332	0.144	0.476	0.776	0.010				0.442	26.41	7.9
9.63	0.004	0.227	0.211	0.436	0.725	0.114				0.701	64.72	13.0
10.63	0.027	0.107	0.267	0.373	0.652	0.171	16.6	0.010	25.000	0.875	113.35	15.2
11.63	0.048	0.059	0.253	0.292	0.507	0.223		0.022		0.972	169.52	16.6
12.63	0.123	0.006	0.189	0.195	0.530	0.317	25.0		24.000	0.982	228.22	17.0
13.63	0.252	0.008	0.147	0.155	0.533	0.363			25.000	0.874	261.06	17.7
14.63	0.238	0.004	0.143	0.147	0.542	0.415				0.709	329.26	18.2
15.63	0.266	0.005	0.137	0.142	0.521	0.408	18.1		17.500	0.472	362.84	18.1
16.63	0.209	0.006	0.132	0.139	0.486	0.385	0.0		2.300	0.197	380.77	17.5
17.63	0.188	0.008	0.125	0.134	0.427	0.330				0.013	385.63	17.7
18.63	0.166	0.007	0.123	0.129	0.300	0.217		0.056		0.0	385.92	10.0
19.63	0.147	0.007	0.120	0.126	0.207	0.139		0.055		0.0	385.92	7.9
20.63	0.132	0.007	0.119	0.126	0.171	0.098		0.050		0.0	385.92	6.4
21.63	0.119	0.009	0.117	0.126				0.050		0.0	385.92	5.4
22.63	0.106	0.008	0.117	0.125				0.050		0.0	385.92	4.4
23.63	0.094	0.008	0.116	0.125				0.052		0.0	385.92	3.6

a/ Interference-corrected initial [NO] is 0.390 ppm.
b/ Data insufficient to permit correction for interference.

85 % SUNSHINE

DAY 2, 10-21-77

TIME (EST)	OZONE (PPH)	NO (PPH)	NO2 (PPH)	NOX (PPH)	I-SUL (PPH)	SU2 (PPH)	I-P-S (UG/M3)	PAN (PPH)	CH-5 (K-CN/CH3)	SR (L/MIN)	CU-SR (LANG) CELSIUS	TEMP (L/MIN)
0.63	0.044	0.008	0.115	0.123				0.054		0.0	0.0	2.9
1.63	0.076	0.008	0.115	0.122				0.054		0.0	0.0	2.1
2.63	0.069	0.007	0.114	0.121				0.046		0.0	0.0	1.6
3.63	0.062	0.006	0.114	0.120				0.054		0.0	0.0	0.9
4.63	0.055	0.006	0.113	0.119				0.056		0.0	0.0	0.5
5.63	0.050	0.006	0.112	0.118	0.010	0.0			0.200	0.0	0.0	0.0
6.63	0.043	0.005	0.111	0.116	0.010	0.0	0.0			0.010	0.38	-0.2
7.63	0.037	0.006	0.111	0.117	0.010	0.010				0.170	7.03	1.7
8.63	0.037	0.008	0.111	0.119	0.010	0.010		0.058		0.410	26.30	6.5
9.63	0.048	0.008	0.113	0.121	0.010	0.010		0.053		0.692	61.56	11.4
10.63	0.076	0.008	0.110	0.118	0.069	0.010		0.051		0.901	110.98	15.3
11.63	0.138	0.006	0.110	0.116	0.095	0.010		0.049		0.920	165.76	16.5
12.63	0.192	0.005	0.104	0.109	0.098	0.058		0.047	2.300	0.725	213.58	17.2
13.63	0.215	0.005	0.103	0.107	0.105	0.010	4.4	0.045	2.200	0.722	256.97	17.7
14.63	0.238	0.003	0.098	0.101	0.090	0.068		0.041		0.663	298.06	18.2
15.63	0.248	0.003	0.095	0.096	0.113	0.010	0.0	0.039		0.417	328.54	18.5
16.63	0.258	0.002	0.087	0.089	0.105	0.010		0.036		0.149	343.43	17.6
17.03									1.000	0.010	346.76	13.8

REF. SMUG CHAMBER STUDY US EPA CONTRACT NO. 6A-02-2437

CHAMBER, NO. 1
DAY 1, 10-22-77
RUN 40 ± 5-CH3-CH3S 100 & SUNSHINE

TIME (EST)	CH2 (PPM)	CH3 (PPM)	CH3S (PPM)	1-SUL (PPM)	SUL2 (PPM)	1-P-S (UG/M3)	PAH (PPM)	CN-S (K-CN/CM3)	SR (L/MIN)	CU-SR (LANG) CELSIUS	TEMP CELSIUS
0-13	0.0	0.0	0.0	0.0	0.0				0.0	0.0	5.7
1-13	0.0	0.001	0.0	0.0	0.0				0.0	0.0	3.0
3-00	0.0	0.137 a/	0.0 b/	0.693	0.0				0.0	0.0	1.9
5-32	0.0	0.141	0.0	0.693	0.0	0.0			0.0	0.0	0.9
6-13	0.0	0.139	0.0	0.688	0.0			0.0	0.012	0.09	0.7
7-13	0.0	0.136	0.0	0.669	0.0	0.0		16.000	0.200	15.57	2.3
8-13	0.004	0.115	0.0	0.657	0.010		0.0	7.200	0.565	39.27	7.0
9-13	0.032	0.059	0.027	0.604	0.010		0.001		0.824	76.81	12.5
10-13	0.077	0.028	0.002	0.511	0.122	16.0	0.001		0.958	127.29	19.9
11-13	0.052	0.021	0.011	0.510	0.175		0.010		0.956	144.76	21.5
12-13	0.052	0.017	0.010	0.506	0.222	14.5	0.010	12.000	0.909	241.28	22.5
13-13	0.059	0.015	0.005	0.496	0.263		0.010	12.000	0.683	290.93	22.9
14-13	0.064	0.010	0.027	0.475	0.284	15.0	0.010	12.000	0.455	330.13	23.0
15-13	0.067	0.008	0.020	0.455	0.293		0.008	2.000	0.185	355.32	21.9
16-13	0.064	0.007	0.020	0.416	0.264 *	7.4	0.008		0.009	365.05	16.9
17-13	0.052	0.007	0.021	0.324	0.198				0.0	365.52	12.4
18-13	0.034	0.005	0.016	0.251	0.143				0.0	365.52	10.7
19-13	0.020	0.004	0.019				0.006		0.0	365.52	9.4
20-13	0.020	0.004	0.018				0.005		0.0	365.52	8.2
21-13	0.012	0.005	0.016				0.007		0.0	365.52	7.3
22-13	0.007	0.005	0.016				0.008		0.0	365.52	6.7
23-13	0.006	0.006	0.017								

a/ Interference-corrected initial [NO] is 0.089 ppm.

b/ Data insufficient to permit correction for interference.

DAY 2, 10-23-77

TIME (EST)	CH2 (PPM)	CH3 (PPM)	CH3S (PPM)	1-SUL (PPM)	SUL2 (PPM)	1-P-S (UG/M3)	PAH (PPM)	CN-S (K-CN/CM3)	SR (L/MIN)	CU-SR (LANG) CELSIUS	TEMP CELSIUS
0-13	0.004	0.006	0.016	0.010	0.010		0.009		0.0	0.0	6.1
1-13	0.001	0.006	0.016	0.010	0.010		0.008		0.0	0.0	5.7
2-13	0.0	0.006	0.019	0.019	0.010		0.009		0.0	0.0	5.3
3-13	0.0	0.005	0.016	0.025	0.010		0.009		0.0	0.0	4.9
4-13	0.0	0.004	0.017	0.021	0.010		0.009		0.0	0.0	4.4
5-13	0.0	0.002	0.017	0.020	0.010		0.009	0.0	0.0	0.0	4.2
6-13	0.0	0.003	0.016	0.021	0.010	0.0	0.011		0.011	0.09	4.1
7-13	0.0	0.006	0.017	0.023	0.010		0.141		0.141	1.76	5.4
8-13	0.007	0.005	0.018	0.028	0.010		0.010		0.404	12.27	11.6
9-13	0.014	0.006	0.016	0.104	0.010		0.010		0.601	36.05	14.9
10-13	0.025	0.005	0.020	0.159	0.074	3.9	0.007		0.786	75.55	17.7
11-13	0.041	0.005	0.020	0.167	0.074			1.600	0.859	123.28	19.3
12-13	0.071	0.005	0.020	0.167	0.074			1.800	0.675	174.93	20.6
13-13	0.071	0.005	0.020	0.167	0.074				0.706	226.01	21.1
14-13	0.104	0.005	0.020	0.170	0.106		0.005		0.511	266.05	21.1
15-13	0.106	0.004	0.020	0.164	0.119		0.005		0.363	296.35	20.5
16-13	0.100	0.005	0.020	0.164	0.119		0.010		0.114	316.19	19.2
17-13	0.075	0.004	0.020	0.200	0.136		0.008		0.010	322.22	17.2
18-13								0.240	0.0	322.74	15.3

COAST GUARD NO. 2
DAY 1, 10-22-77
RUN 90 : 3-113-4413 100 & 505510104

TIME (CST)	0200dL (PPH)	01 (PPH)	0102 (PPH)	0103 (PPH)	1-SUL (PPH)	SO2 (PPH)	1-P-S (UG/H3)	PAN (PPH)	CH-5 (K-CH/CHX)	SM (L/MIN)	CU-SR (ANG)	TPMD CELSIUS
0.30	0.0	0.001	0.0	0.001	0.0	0.0				0.0	0.0	3.7
1.30	0.0	0.005	0.0	0.005	0.0	0.0				0.0	0.0	3.0
3.50	0.0	0.213	0.0	0.005	0.0	0.0				0.0	0.0	1.9
4.90	0.0	0.214	0.006	0.226	0.643	0.0				0.0	0.0	1.4
5.65	0.0	0.217	0.006	0.225	0.643	0.0				0.0	0.0	0.9
6.30	0.0	0.216	0.006	0.222	0.634	0.0			0.0	0.012	0.22	0.7
7.30	0.0	0.209	0.006	0.216	0.625	0.0	0.0		16.000	0.200	0.12	2.3
8.00	0.004	0.177	0.032	0.209	0.609	0.010	0.0	0.000		0.365	19.29	7.0
9.30	0.029	0.093	0.066	0.179	0.551	0.010	28.9		10.000	0.596	45.35	12.5
10.30	0.135	0.024	0.062	0.087	0.453	0.156		0.008		0.824	85.21	16.9
11.30	0.106	0.008	0.049	0.057	0.442	0.263		0.017		0.950	137.06	19.9
12.30	0.149	0.004	0.053	0.057	0.440	0.303	16.4		15.500	0.956	194.51	21.5
13.30	0.165	0.003	0.050	0.054	0.445	0.321			15.500	0.849	249.94	22.5
14.30	0.167	0.003	0.051	0.054	0.429	0.320	26.6		11.500	0.683	297.89	22.9
15.30	0.177	0.002	0.047	0.050	0.412	0.312			8.500	0.455	334.77	23.0
16.30	0.194	0.002	0.045	0.047	0.340	0.315			1.000	0.185	357.21	21.9
17.30	0.194	0.002	0.045	0.047	0.340	0.315				0.009	365.14	16.9
18.30	0.194	0.002	0.041	0.043	0.368	0.274	4.9			0.0	365.52	12.4
19.30	0.194	0.001	0.039	0.040	0.258	0.194				0.0	365.52	10.7
20.30	0.155	0.001	0.037	0.038	0.177	0.117		0.014		0.0	365.52	9.4
21.30	0.117	0.002	0.037	0.039				0.016		0.0	365.52	8.2
22.30	0.081	0.003	0.036	0.039				0.016		0.0	365.52	7.3
23.30	0.091	0.003	0.035	0.037	0.013			0.013		0.0	365.52	6.7
24.30	0.071	0.003	0.035	0.035				0.016		0.0	365.52	6.7

a/ Interference-corrected initial $[\text{NO}]$, $[\text{NO}_2]$, and $[\text{NO}_x]$ are 0.164, 0.045, and 0.209 ppm.

DAY 2, 10-23-17

TIME (H:SI)	U ₂ /H (PPH)	OH (PPH)	NO ₂ (PPH)	NOX (PPH)	1-SUL (PPH)	SUL ₂ (PPH)	1-P-S (UG/H3)	PAN (PPH)	CH-5 (N-CN/CH3)	SH (L/MIN)	CU-SR (LANG)	TEMP Celsius
0:50	0.068	0.004	0.055	0.059				0.017		0.0	0.0	6.1
1:50	0.062	0.001	0.055	0.057				0.017		0.0	0.0	5.7
2:50	0.072	0.001	0.056	0.057				0.017		0.0	0.0	5.3
3:50	0.066	0.0	0.056	0.056				0.017		0.0	0.0	4.9
4:50	0.059	0.0	0.055	0.055				0.017		0.0	0.0	4.4
5:50	0.055	0.0	0.055	0.055	0.010	0.0		0.014	0.0	0.0	0.0	4.2
6:50	0.077	0.001	0.056	0.056	0.010	0.0	0.0	0.017	0.011	0.20	0.20	4.1
7:50	0.075	0.001	0.056	0.057	0.010	0.0		0.017	0.141	3.20	3.20	5.4
8:50	0.075	0.002	0.056	0.056	0.010	0.010		0.015	0.404	16.59	16.59	11.6
9:50	0.075	0.003	0.057	0.060	0.010	0.010			0.601	44.18	44.18	14.9
10:50	0.076	0.025	0.056	0.060	0.010	0.010			0.786	83.57	83.57	17.7
11:50	0.074	0.026	0.056	0.060	0.075	0.010	5.5		0.859	132.04	132.04	19.3
12:50	0.150	0.055	0.057	0.062	0.077	0.010			0.853	183.63	183.63	20.6
13:50	0.150	0.055	0.056	0.060	0.081	0.057			0.706	253.21	253.21	21.1
14:50	0.165	0.065	0.056	0.060	0.090	0.060			0.511	272.06	272.06	21.5
15:50	0.165	0.064	0.055	0.055	0.090	0.060			0.464	300.05	300.05	20.5
16:50	0.161	0.064	0.056	0.056	0.104	0.062			0.114	517.15	517.15	19.2
17:50	0.177	0.065	0.065	0.065	0.127	0.071			0.010	522.52	522.52	17.2
18:50	0.167	0.064	0.055	0.059			0.0		0.210	0.0	0.0	15.3

RTI SHIMS CHAMBER STUDY
USEPA CONTRACT NO. 68-02-2437

CHAMBER NO. 5
DAY 1, 10-22-77
RUN 40: 3-ETH-CHMS 100 & SUNSHINE

TIME (LST)	020-R (PPM)	NO (PPM)	NO ₂ (PPM)	NOX (PPM)	I-SUL (PPM)	SO ₂ (PPM)	I-P-S (UG/H3)	PAH (PPM)	CH-S (K-CN/CM3)	SR (L/MIN)	CU-SR (LANG) CELSIUS	TEMP CELSIUS
0.47	0.0	0.006	0.000	0.006	0.0	0.0				0.0	0.0	3.7
1.47	0.0	0.005	0.002	0.008	0.0	0.0				0.0	0.0	3.0
3.23	0.0	0.450	0.0	0.450	0.609	0.0			0.0	0.0	0.0	1.9
4.63	0.0	0.448	0.065	0.510	0.682	0.0			0.0	0.0	0.0	1.4
5.00	0.0	0.438	0.064	0.502	0.682	0.0	0.0		0.0	0.0	0.0	0.9
6.47	0.0	0.438	0.066	0.504	0.674	0.0			0.0	0.012	0.34	0.7
7.47	0.0	0.422	0.071	0.493	0.666	0.0	0.0		22.000	0.200	6.36	2.3
8.47	0.0	0.507	0.109	0.476	0.641	0.010				0.365	23.01	7.0
9.47	0.007	0.252	0.109	0.401	0.577	0.010		0.001	6.900	0.596	51.43	12.5
10.47	0.043	0.087	0.260	0.347	0.505	0.168	21.8	0.005		0.824	93.62	16.9
11.47	0.153	0.021	0.217	0.238	0.483	0.302		0.016		0.956	146.84	19.9
12.47	0.256	0.005	0.157	0.163			50.0		12.000	0.849	204.26	21.5
13.47	0.329	0.003	0.120	0.123	0.501	0.389			12.000	0.683	258.60	22.5
14.47	0.368	0.003	0.101	0.104	0.488	0.384	57.1		11.500	0.455	304.86	22.9
15.47	0.369	0.002	0.091	0.092	0.481	0.378			9.100	0.185	339.41	23.0
16.47	0.349	0.002	0.081	0.083	0.479	0.374			2.400	0.009	359.10	21.9
17.47	0.311	0.001	0.071	0.073	0.411	0.318	10.6			0.0	365.23	16.9
18.47	0.272	0.001	0.065	0.067	0.303	0.223				0.0	365.52	12.4
19.47	0.243	0.001	0.065	0.066	0.231	0.168		0.028		0.0	365.52	10.7
20.47	0.216	0.001	0.064	0.065				0.028		0.0	365.52	9.4
21.47	0.195	0.003	0.063	0.065				0.027		0.0	365.52	8.2
22.47	0.177	0.004	0.064	0.067				0.028		0.0	365.52	7.5
23.47	0.156	0.004	0.064	0.068				0.028		0.0	365.52	6.7

a/ Interference-corrected initial [NO], [NO₂], and [NO_x] are 0.396, 0.098, and 0.494 ppm.

DAY 2, 10-23-77

RO & SUNSHINE

TIME (LST)	020-R (PPM)	NO (PPM)	NO ₂ (PPM)	NOX (PPM)	I-SUL (PPM)	SO ₂ (PPM)	I-P-S (UG/H3)	PAH (PPM)	CH-S (K-CN/CM3)	SR (L/MIN)	CU-SR (LANG) CELSIUS	TEMP CELSIUS
0.47	0.140	0.004	0.003	0.007	0.010	0.0		0.030		0.0	0.0	6.1
1.47	0.127	0.001	0.003	0.005	0.010	0.010		0.030		0.0	0.0	5.7
2.47	0.116	0.000	0.000	0.000	0.010	0.010		0.031		0.0	0.0	5.3
3.47	0.104	0.0	0.004	0.004	0.010	0.010		0.030		0.0	0.0	4.9
4.47	0.093	0.000	0.004	0.004	0.010	0.010		0.031		0.0	0.0	4.4
5.47	0.080	0.0	0.004	0.004	0.010	0.010		0.031	0.0	0.0	0.0	4.2
6.47	0.070	0.001	0.004	0.005	0.010	0.010	0.0	0.031		0.011	0.31	4.1
7.47	0.058	0.000	0.004	0.004	0.010	0.010		0.031		0.101	4.64	3.4
8.47	0.054	0.002	0.004	0.006	0.010	0.010		0.029		0.404	20.51	11.6
9.47	0.067	0.003	0.005	0.006	0.010	0.010				0.601	50.31	14.9
10.47	0.098	0.006	0.004	0.007	0.067	0.010				0.786	91.59	17.7
11.47	0.151	0.005	0.004	0.009	0.095	0.052			2.700	0.859	140.40	19.3
12.47	0.197	0.009	0.004	0.005	0.106	0.010	6.0		5.400	0.875	192.74	20.6
13.47	0.250	0.005	0.004	0.005	0.117	0.064				0.706	240.41	21.1
14.47	0.243	0.004	0.004	0.004	0.127	0.078				0.511	277.27	21.1
15.47	0.243	0.004	0.004	0.006	0.150	0.097				0.363	303.76	20.5
16.47	0.256	0.005	0.004	0.006	0.158	0.103				0.114	318.51	19.2
17.47	0.216	0.005	0.004	0.009	0.158	0.103			0.200	0.010	322.42	17.2
18.47		0.005	0.004	0.009			5.4			0.0	322.74	15.3

RTI SMUG CHAMBER STUDY
US EPA CINCINNATI HQ, OH-02-2437

CHAMBER NO. 4
DAY 1, 10-22-77
R04 Q0 5-CH3-C4H8 100 % SUNSHINE

TIME (EST)	OZONE (PPH)	CO (PPH)	CO2 (PPH)	NOX (PPH)	I-SUL (PPH)	SUL2 (PPH)	I-P-S (UG/H3)	PAN (PPH)	CH-5 (K-CN/CM3)	SH (L/MIN)	CU-SR (LANG)	TEMP CELSIUS
0.65	0.0	0.002	0.001	0.005	0.0	0.0				0.0	0.0	5.7
1.65	0.0	0.004	0.002	0.006	0.0	0.0				0.0	0.0	3.0
2.90	0.0	0.046	0.0	0.046	0.665	0.0				0.0	0.0	2.4
4.23	0.0	0.021	0.138	0.979	0.655	0.0				0.0	0.0	1.4
5.97	0.0	0.179	0.177	0.966	0.655	0.0	0.0			0.0	0.0	0.9
6.65	0.0	0.178	0.185	0.962	0.648	0.0			0.0	0.012	0.45	0.7
7.65	0.0	0.150	0.294	0.954	0.636	0.0	0.0		24.000	0.200	4.28	2.3
8.65	0.0	0.074	0.241	0.915	0.606	0.010		0.009		0.365	26.52	7.0
9.65	0.001	0.056	0.304	0.859	0.546	0.010				0.596	57.15	12.5
10.65	0.006	0.369	0.408	0.777	0.485	0.139	15.2	0.002	0.000	0.824	101.53	16.9
11.65	0.014	0.215	0.462	0.677	0.471	0.240		0.004		0.958	156.03	19.9
12.65	0.635	0.124	0.402	0.586	0.467	0.312	15.3		12.000	0.956	213.44	21.5
13.65	0.049	0.082	0.440	0.522	0.460	0.358	29.2		11.000	0.849	266.75	22.9
14.65	0.054	0.060	0.412	0.475	0.455	0.345			7.300	0.683	311.42	23.0
15.65	0.051	0.046	0.393	0.438	0.455	0.350			2.900	0.055	343.78	21.9
16.65	0.035	0.031	0.301	0.412	0.441	0.342	4.8			0.185	360.87	16.9
17.65	0.007	0.013	0.377	0.590	0.372	0.278				0.009	365.32	12.4
18.65	0.001	0.011	0.375	0.585	0.276	0.192		0.006		0.0	365.52	10.7
19.65	0.0	0.011	0.360	0.577	0.218	0.146				0.0	365.52	9.4
20.65	0.0	0.013	0.361	0.574				0.008		0.0	365.52	8.2
21.65	0.0	0.016	0.555	0.572				0.004		0.0	365.52	7.3
22.65	0.0	0.016	0.553	0.569				0.006		0.0	365.52	6.7
23.65	0.0	0.020	0.345	0.565				0.006		0.0	365.52	6.7

a/ Interference-corrected initial [NO], [NO2], and [NOx] are 0.773, 0.193, and 0.966 ppm.

DAY 2, 10-23-77

NO 2 SUNSHINE

TIME (EST)	OZONE (PPH)	CO (PPH)	CO2 (PPH)	NOX (PPH)	I-SUL (PPH)	SUL2 (PPH)	I-P-S (UG/H3)	PAN (PPH)	CH-5 (K-CN/CM3)	SH (L/MIN)	CU-SR (LANG)	TEMP CELSIUS
0.65	0.0	0.022	0.559	0.561	0.010	0.0		0.008		0.0	0.0	6.1
1.65	0.0	0.019	0.552	0.550	0.010	0.0		0.009		0.0	0.0	5.7
2.65	0.0	0.020	0.526	0.545	0.010	0.0		0.006		0.0	0.0	5.3
3.65	0.0	0.019	0.516	0.536	0.010	0.0		0.009		0.0	0.0	4.9
4.65	0.0	0.021	0.515	0.555	0.010	0.0		0.009		0.0	0.0	4.4
5.65	0.0	0.021	0.507	0.528	0.010	0.0		0.009	0.0	0.0	0.0	4.2
6.65	0.004	0.051	0.225	0.524	0.010	0.0	0.0	0.008		0.011	5.42	4.1
7.65	0.010	0.059	0.244	0.505	0.010	0.0		0.009		0.141	5.99	5.4
8.65	0.014	0.077	0.189	0.265	0.010	0.0		0.008		0.404	24.59	11.6
9.65	0.022	0.092	0.165	0.250	0.010	0.0				0.601	56.08	14.9
10.65	0.036	0.047	0.169	0.215	0.010	0.0	5.5		5.600	0.786	99.13	17.7
11.65	0.053	0.055	0.165	0.196	0.010	0.0			5.000	0.859	149.05	19.5
12.65	0.073	0.025	0.155	0.176	0.127	0.080				0.873	201.12	20.6
13.65	0.090	0.016	0.145	0.159	0.142	0.089				0.706	247.19	21.1
14.65	0.094	0.013	0.154	0.147	0.159	0.127				0.511	282.18	21.1
15.65	0.091	0.010	0.154	0.154	0.159	0.127				0.565	307.24	20.5
16.65	0.094	0.010	0.154	0.154	0.159	0.127				0.114	319.61	19.2
17.65	0.092	0.008	0.116	0.124	0.141	0.126			0.560	0.010	322.52	17.2
18.65	0.092	0.005	0.077	0.107			6.4			0.0	322.74	15.5

CHARTERED 100, 1
DAY 1, 10-30-7
RUN 41 : 2-11

TIME (EST)	NO2/HR (PPHM)	NO (PPHM)	NO2 (PPHM)	NO2 (PPHM)	1-SUL (PPHM)	SUL2 (PPHM)	T-P-S (UG/N3)	PAR (PPHM)	CM-5 (N-CN/CM3)	SR (L/MIN)	CU-SN (LANG)	TEMP CELSIUS
0.15	0.001	0.005	0.0	0.005	0.0	0.0				0.0	0.0	8.3
1.30	0.002	0.009	0.0	0.009	0.556	0.0				0.0	0.0	6.9
2.15	0.0	0.008	0.0	0.008	0.556	0.0				0.0	0.0	5.9
3.60	0.0	0.100	0.0	0.100	0.552	0.0				0.0	0.0	6.0
5.15	0.0	0.101	0.014	0.115	0.550	0.0				0.0	0.0	7.2
6.15	0.0	0.100	0.014	0.110	0.553	0.0	5.9		0.0	0.006	0.05	6.9
7.15	0.0102	0.099	0.010	0.113	0.525	0.0			26.000	0.093	1.09	6.8
8.15	0.0104	0.085	0.025	0.108	0.527	0.0	10.5		19.000	0.419	9.21	9.8
9.15	0.022	0.059	0.051	0.090	0.470	0.0				0.580	55.60	11.9
10.15	0.075	0.015	0.657	0.052	0.390	0.0		0.006	16.000	0.742	71.67	13.7
11.15	0.068	0.007	0.622	0.029	0.327	0.0	21.6	0.012	17.500	0.804	116.67	14.8
12.15	0.055	0.006	0.625	0.029	0.303	0.010		0.012	17.500	0.977	166.26	16.4
13.15	0.046	0.007	0.627	0.026	0.266	0.010	11.1	0.013		0.682	224.14	17.1
14.15	0.043	0.007	0.621	0.028	0.242	0.010		0.012		0.725	275.82	17.7
15.15	0.038	0.008	0.620	0.026	0.217	0.010		0.011		0.418	316.82	17.4
16.15	0.054	0.008	0.618	0.026	0.202	0.010		0.011	7.400	0.167	359.94	16.4
17.15	0.026	0.007	0.619	0.026	0.187	0.010	0.0	0.011		0.002	348.67	12.7
18.15	0.019	0.004	0.618	0.022	0.159	0.010		0.010		0.0	348.78	10.0
19.15	0.015	0.004	0.616	0.020	0.142	0.010		0.010		0.0	348.78	8.2
20.15	0.010	0.004	0.617	0.022	0.135	0.0		0.010		0.0	348.78	7.4
21.15	0.008	0.004	0.617	0.021	0.127	0.0		0.010		0.001	348.79	6.1
22.15	0.006	0.006	0.618	0.025	0.117	0.0		0.010		0.001	348.85	5.4
23.15	0.006	0.008	0.618	0.023	0.115	0.0		0.010		0.001	348.91	4.4

a/ Interference-corrected initial $[NO]$, $[NO_2]$, and $[NO_A]$ are 0.096, 0.018, and 0.114 ppm.

49 X SINSHIUT.

TIME (H:51)	WZ40R (PPM)	WZ (PPM)	1-02 (PPM)	1-03 (PPM)	1-SUL (PPM)	SUL2 (PPM)	1-P-S (UG/H5)	PAN (PPM)	CN-S (N-CH/CH3)	SH (L/MIN)	CU-SH (LANG)	TEMP CELSIUS
0.13	0.000	0.006	0.010	0.022	0.153	0.010		0.009		0.001	0.01	3.6
1.13	0.005	0.005	0.017	0.022	0.121	0.0		0.010		0.001	0.07	3.6
2.13	0.005	0.005	0.017	0.022	0.119	0.0		0.013		0.001	0.13	4.1
3.13	0.005	0.006	0.010	0.022	0.119	0.0		0.009		0.0	0.10	4.4
4.13	0.000	0.005	0.010	0.019	0.120	0.0		0.009		0.0	0.14	4.9
5.13	0.001	0.002	0.010	0.018	0.117	0.0		0.009	0.0	0.0	0.18	5.1
6.13	0.002	0.002	0.010	0.018	0.114	0.0	0.0	0.008		0.008	0.24	5.1
7.13	0.005	0.011	0.017	0.018	0.112	0.0		0.007		0.130	1.67	5.9
8.13	0.005	0.002	0.015	0.016	0.108	0.0		0.008	0.530	0.680	11.03	6.3
9.13	0.008	0.003	0.015	0.018	0.112	0.0		0.009	0.560	0.680	33.56	10.9
10.13	0.008	0.004	0.016	0.020	0.111	0.010		0.009		0.099	72.95	12.4
11.13	0.015	0.004	0.016	0.020	0.106	0.010		0.009	8.000	0.178	105.07	14.1
12.13	0.025	0.004	0.016	0.021	0.109	0.010	0.0	0.009		0.168	150.50	15.0
13.13	0.027	0.005	0.017	0.020	0.095	0.010		0.008	10.700	0.501	185.73	15.1
14.13	0.026	0.004	0.017	0.021	0.086	0.010		0.009		0.297	207.94	15.2
15.13	0.025	0.004	0.016	0.020	0.085	0.010		0.008		0.242	225.33	15.1
16.13	0.024	0.004	0.015	0.018	0.079	0.010		0.008		0.075	236.84	14.6
17.13	0.024	0.005	0.015	0.018	0.079	0.010	0.0	0.008		0.005	242.50	13.6

CHAMBER STUDY
DAY 1, 10-30-77
MIN 41 2 2-CH3-CH35 90 2 30-50-104

TIME (LS)	UO ₂ L (PPH)	HI (PPH)	HI ² (PPH)	HI ³ (PPH)	I-SUL (PPH)	SUL ² (PPH)	I-P-S (UG/MS)	PAH (PPH)	CH-S (K-CH/CM)	SR (L/MIN)	CU-SH (LANG) CELSIUS	TEMP (C)
0.30	0.002	0.003	0.0	0.003	0.0	0.0				0.0	0.0	6.1
1.47	0.003	0.008	0.0	0.008	0.538	0.0				0.0	0.0	6.9
2.30	0.001	0.008	0.0	0.008	0.532	0.0				0.0	0.0	5.9
3.37	0.0	0.172	0.0	0.172	0.534	0.0				0.0	0.0	6.7
4.83	0.0	0.173	0.0	0.173	0.516	0.0				0.0	0.0	7.4
5.30	0.0	0.174	0.0	0.174	0.527	0.0				0.0	0.0	7.2
6.30	0.0	0.169	0.0	0.169	0.515	0.0	2.1		0.0	0.006	0.11	6.9
7.50	0.002	0.166	0.036	0.166	0.500	0.0			26.000	0.093	2.03	6.8
9.30	0.004	0.147	0.052	0.147	0.499	0.0	7.4		21.000	0.419	13.48	9.8
10.30	0.015	0.089	0.093	0.142	0.450	0.0				0.580	41.52	11.9
11.30	0.118	0.088	0.104	0.150	0.376	0.0			19.000	0.742	79.24	13.7
12.30	0.129	0.095	0.086	0.078	0.295	0.0	29.3	0.006	17.500	0.804	176.43	14.8
13.30	0.115	0.096	0.045	0.051	0.254	0.010		0.015		0.977	253.14	17.1
14.30	0.108	0.086	0.043	0.050	0.225	0.002	22.4	0.023		0.723	283.14	17.1
15.30	0.105	0.086	0.043	0.050	0.201	0.002		0.023		0.410	321.00	17.4
16.30	0.076	0.087	0.043	0.049	0.183	0.005		0.022		0.167	341.65	16.4
17.30	0.085	0.087	0.041	0.048	0.177	0.005		0.022		0.002	348.70	12.7
18.30	0.071	0.084	0.040	0.044	0.145	0.010	0.0	0.021		0.0	348.78	10.0
19.30	0.060	0.081	0.039	0.040	0.099	0.010		0.020		0.0	348.78	8.2
20.30	0.053	0.081	0.037	0.039	0.073	0.010		0.020		0.001	348.80	6.1
21.30	0.047	0.082	0.035	0.037	0.010	0.010		0.020		0.001	348.86	5.4
22.30	0.042	0.085	0.037	0.041	0.019	0.0		0.020		0.001	348.92	4.4
23.30	0.037	0.085	0.035	0.040	0.010	0.0		0.020		0.001		

Interference-corrected Initial [H₂], [H₂O], and [H₂O₂] are 0.167, 0.042, and 0.209 ppm.

DAY 2, 10-31-77

49 X 30-50-104

TIME (LS)	UO ₂ L (PPH)	HI (PPH)	HI ² (PPH)	HI ³ (PPH)	I-SUL (PPH)	SUL ² (PPH)	I-P-S (UG/MS)	PAH (PPH)	CH-S (K-CH/CM)	SR (L/MIN)	CU-SH (LANG) CELSIUS	TEMP (C)
0.30	0.034	0.003	0.035	0.038	0.010	0.010		0.020		0.001	0.02	3.6
1.30	0.030	0.003	0.035	0.038	0.010	0.0		0.019		0.001	0.00	3.6
2.30	0.028	0.009	0.033	0.037	0.010	0.0		0.019		0.001	0.14	4.1
3.30	0.024	0.002	0.035	0.037	0.010	0.0		0.018		0.0	0.18	4.4
4.30	0.019	0.001	0.034	0.036	0.010	0.0		0.018		0.0	0.18	4.9
5.30	0.016	0.001	0.034	0.035	0.010	0.0		0.015	0.0	0.008	0.16	5.1
6.30	0.015	0.001	0.034	0.035	0.010	0.0	0.0	0.015		0.008	0.12	5.1
7.30	0.013	0.001	0.034	0.035	0.010	0.0		0.014		0.008	0.10	5.9
8.30	0.014	0.001	0.034	0.035	0.010	0.0		0.014		0.008	0.10	6.3
9.30	0.020	0.002	0.034	0.035	0.010	0.0		0.014		0.008	0.10	10.9
10.30	0.020	0.003	0.034	0.035	0.010	0.010		0.014		0.009	0.10	12.4
11.30	0.020	0.003	0.034	0.035	0.010	0.010		0.014		0.009	0.10	14.1
12.30	0.020	0.003	0.034	0.035	0.010	0.010	0.0	0.014	15.500	0.018	156.80	15.0
13.30	0.020	0.003	0.034	0.035	0.010	0.010		0.014	9.800	0.018	169.62	15.1
14.30	0.020	0.003	0.034	0.035	0.010	0.010		0.015	6.000	0.015	210.97	15.2
15.30	0.020	0.003	0.034	0.035	0.010	0.010	0.0	0.015	6.000	0.015	227.80	15.1
16.30	0.020	0.003	0.034	0.035	0.010	0.010		0.014	5.300	0.014	239.31	14.8
17.30	0.020	0.003	0.034	0.035	0.010	0.010	0.0	0.014	5.100	0.014	242.55	13.6

W11 SMITH, CHAMBER STUDY
DISPERA LITHIUM (NO), 68-02-2437

CHAMBER NO. 3
DAY 1, 10-30-77
MIN 01 3 2-0113-4.0115 99 & 500000000

TIME (EST)	U2O4 (PPM)	CO (PPM)	NO2 (PPM)	NO (PPM)	1-SUL (PPM)	502 (PPM)	1-P-S (PPM)	PAH (PPM)	IN-5 (K-CN/LM3)	SR (L/MIN)	CU-SH (LANG) CELSIUS	TEMP CELSIUS
0.47	0.009	0.003	0.0	0.003	0.0	0.0				0.0	0.0	8.3
1.63	0.009	0.009	0.0	0.009	0.505	0.0				0.0	0.0	6.9
2.47	0.003	0.009	0.0	0.009	0.518	0.0				0.0	0.0	5.9
3.13	0.0	0.0	0.0	0.0	0.523	0.0				0.0	0.0	6.7
4.47	0.0	0.0	0.0	0.0	0.529	0.0				0.0	0.0	7.9
5.47	0.0	0.0	0.0	0.0	0.509	0.0				0.0	0.0	7.2
6.47	0.0	0.0	0.0	0.0	0.509	0.0				0.0	0.0	6.9
7.47	0.0	0.0	0.0	0.0	0.509	0.0				0.0	0.0	6.8
8.47	0.0	0.0	0.0	0.0	0.509	0.0				0.0	0.0	6.8
9.47	0.0	0.0	0.0	0.0	0.509	0.0				0.0	0.0	6.8
10.47	0.0	0.0	0.0	0.0	0.509	0.0				0.0	0.0	6.8
11.47	0.0	0.0	0.0	0.0	0.509	0.0				0.0	0.0	6.8
12.47	0.0	0.0	0.0	0.0	0.509	0.0				0.0	0.0	6.8
13.47	0.0	0.0	0.0	0.0	0.509	0.0				0.0	0.0	6.8
14.47	0.0	0.0	0.0	0.0	0.509	0.0				0.0	0.0	6.8
15.47	0.0	0.0	0.0	0.0	0.509	0.0				0.0	0.0	6.8
16.47	0.0	0.0	0.0	0.0	0.509	0.0				0.0	0.0	6.8
17.47	0.0	0.0	0.0	0.0	0.509	0.0				0.0	0.0	6.8
18.47	0.0	0.0	0.0	0.0	0.509	0.0				0.0	0.0	6.8
19.47	0.0	0.0	0.0	0.0	0.509	0.0				0.0	0.0	6.8
20.47	0.0	0.0	0.0	0.0	0.509	0.0				0.0	0.0	6.8
21.47	0.0	0.0	0.0	0.0	0.509	0.0				0.0	0.0	6.8
22.47	0.0	0.0	0.0	0.0	0.509	0.0				0.0	0.0	6.8
23.47	0.0	0.0	0.0	0.0	0.509	0.0				0.0	0.0	6.8

s/ Interference-corrected initial [NO], [NO2], and [NOx] are 0.412, 0.001, and 0.503 ppm.

DAY 2, 10-31-77

TIME (EST)	U2O4 (PPM)	CO (PPM)	NO2 (PPM)	NO (PPM)	1-SUL (PPM)	502 (PPM)	1-P-S (PPM)	PAH (PPM)	CU-S (K-CN/LM3)	SR (L/MIN)	CU-SH (LANG) CELSIUS	TEMP CELSIUS
0.47	0.003	0.003	0.100	0.111	0.010	0.0				0.001	0.03	3.6
1.47	0.002	0.003	0.103	0.111	0.010	0.0				0.001	0.09	3.6
2.47	0.001	0.007	0.109	0.111	0.010	0.0				0.001	0.15	4.1
3.47	0.001	0.006	0.103	0.109	0.010	0.0				0.0	0.18	4.8
4.47	0.001	0.009	0.101	0.105	0.010	0.0				0.0	0.18	4.9
5.47	0.0	0.009	0.098	0.103	0.010	0.0			0.0	0.0	0.18	5.1
6.47	0.002	0.009	0.098	0.103	0.010	0.0			0.0	0.008	0.41	5.1
7.47	0.003	0.014	0.098	0.098	0.010	0.0			0.0	0.130	4.33	5.9
8.47	0.039	0.011	0.092	0.073	0.010	0.0			0.0	0.330	17.77	8.3
9.47	0.039	0.039	0.098	0.098	0.010	0.0			0.0	0.660	47.44	10.9
10.47	0.038	0.038	0.098	0.098	0.010	0.0			0.0	0.660	47.44	10.9
11.47	0.038	0.038	0.098	0.098	0.010	0.0			0.0	0.660	47.44	10.9
12.47	0.115	0.039	0.098	0.098	0.010	0.0			0.0	0.660	47.44	10.9
13.47	0.115	0.039	0.098	0.098	0.010	0.0			0.0	0.660	47.44	10.9
14.47	0.115	0.039	0.098	0.098	0.010	0.0			0.0	0.660	47.44	10.9
15.47	0.115	0.039	0.098	0.098	0.010	0.0			0.0	0.660	47.44	10.9
16.47	0.115	0.039	0.098	0.098	0.010	0.0			0.0	0.660	47.44	10.9
17.47	0.115	0.039	0.098	0.098	0.010	0.0			0.0	0.660	47.44	10.9

RII SMUG (HAMMER STUDY) USLPA CONTRACT NO. 68-02-2437

CHAMBER NO. 4
DAY 1, 10-30-77
RUN 41 : 2-CH3-CH3SS 90 X SUNSHINE

TIME (EST)	UZ/HR (PPH)	RU (PPH)	RU2 (PPH)	RU3 (PPH)	1-SUL (PPH)	SU2 (PPH)	1-P-S (UG/MS)	PAN (PPH)	CH-5 (K-CH/CM3)	SR (L/MIN)	CU-SR (LANG) CELSIUS	TEMP (CELSIUS)
0.63	0.002	0.004	0.0	0.004	0.0	0.0				0.0	0.0	8.3
1.63	0.002	0.007	0.0	0.007	0.0	0.0				0.0	0.0	6.9
2.63	0.001	0.008	0.0	0.008	0.0	0.0				0.0	0.0	5.9
3.63	0.0	0.009	0.0	0.009	0.0	0.0				0.0	0.0	6.7
5.63	0.0	0.009	0.0	0.009	0.0	0.0				0.0	0.0	7.2
6.63	0.0	0.009	0.0	0.009	0.0	0.0				0.0	0.0	6.9
7.63	0.002	0.009	0.0	0.009	0.0	0.0	2.6		0.0	0.006	0.23	6.6
8.63	0.001	0.009	0.0	0.009	0.0	0.0	5.1		35.500	0.093	3.68	6.6
9.63	0.003	0.009	0.0	0.009	0.0	0.0			26.000	0.419	21.78	9.6
10.63	0.003	0.009	0.0	0.009	0.0	0.0				0.540	53.00	11.9
11.63	0.006	0.009	0.0	0.009	0.0	0.0				0.742	93.93	13.7
12.63	0.006	0.009	0.0	0.009	0.0	0.0				0.604	140.79	14.8
13.63	0.006	0.009	0.0	0.009	0.0	0.0				0.977	195.57	16.4
14.63	0.004	0.009	0.0	0.009	0.0	0.0				0.662	250.60	17.1
15.63	0.006	0.009	0.0	0.009	0.0	0.0				0.723	297.51	17.7
16.63	0.006	0.009	0.0	0.009	0.0	0.0				0.418	329.36	17.4
17.63	0.006	0.009	0.0	0.009	0.0	0.0				0.167	344.95	16.4
18.63	0.004	0.009	0.0	0.009	0.0	0.0				0.002	348.73	12.7
19.63	0.0	0.009	0.0	0.009	0.0	0.0				0.0	348.78	10.6
20.63	0.0	0.009	0.0	0.009	0.0	0.0				0.0	348.78	6.2
21.63	0.0	0.009	0.0	0.009	0.0	0.0				0.001	348.82	6.1
22.63	0.0	0.009	0.0	0.009	0.0	0.0				0.001	348.88	5.4
23.63	0.0	0.009	0.0	0.009	0.0	0.0				0.001	348.94	4.4

a/ Interference-corrected initial [NO], [NO₂], and [NO_x] are 0.792, 0.203, and 0.995 ppm.

DAY 2, 10-31-77

49 X SUNSHINE

TIME (EST)	UZ/HR (PPH)	RU (PPH)	RU2 (PPH)	RU3 (PPH)	1-SUL (PPH)	SU2 (PPH)	1-P-S (UG/MS)	PAN (PPH)	CH-5 (K-CH/CM3)	SR (L/MIN)	CU-SR (LANG) CELSIUS	TEMP (CELSIUS)
0.63	0.0	0.231	0.315	0.346	0.010	0.0				0.001	0.04	5.6
1.63	0.0	0.229	0.311	0.340	0.073	0.0				0.001	0.10	3.6
2.63	0.0	0.231	0.311	0.340	0.068	0.0				0.001	0.16	4.1
3.63	0.0	0.227	0.305	0.332	0.069	0.0				0.0	0.14	4.8
4.63	0.0	0.221	0.304	0.325	0.079	0.0				0.0	0.18	4.9
5.63	0.0	0.219	0.300	0.320	0.010	0.0				0.0	0.14	5.1
6.63	0.001	0.218	0.294	0.312	0.010	0.0	0.0			0.008	0.44	5.1
7.63	0.004	0.222	0.297	0.317	0.010	0.0				0.130	5.57	8.3
8.63	0.006	0.229	0.290	0.305	0.010	0.0				0.350	20.93	8.3
9.63	0.006	0.221	0.280	0.305	0.010	0.0				0.600	53.96	10.9
10.63	0.005	0.200	0.265	0.306	0.010	0.0				0.499	87.92	12.4
11.63	0.007	0.182	0.244	0.286	0.010	0.0				0.778	128.41	14.1
12.63	0.007	0.164	0.220	0.266	0.010	0.0	14.4		5.500	0.618	169.04	15.0
13.63	0.006	0.156	0.213	0.259	0.010	0.0			5.100	0.581	197.16	15.1
14.63	0.006	0.147	0.201	0.249	0.010	0.0				0.297	216.45	15.2
15.63	0.005	0.143	0.189	0.232	0.010	0.0				0.242	232.59	15.1
16.63	0.004	0.136	0.185	0.221	0.010	0.0				0.075	240.79	14.6
17.63	0.004	0.136	0.185	0.221	0.010	0.0				0.005	242.65	13.6

RTI SMOG CHAMBER STUDY
US EPA CONTRACT NO. 68-02-2437

CHAMBER NO. 1
DAY 1, 11-9-77
RUN 32: C13-S-C205

71 % SUNSHINE

TIME (EST)	OZONE (PPM)	CO (PPM)	NO ₂ (PPM)	NOX (PPM)	I-SOL (PPM)	SOL ₂ (PPM)	I-P-S (UG/H3)	PM ₁₀ (PPM)	CH-5 (K-CH/CM3)	SH (L/MIN)	CU-SH (LANG) CELSIUS	TEMP CELSIUS
0.13	0.0	0.0	0.0	0.0	0.0	0.0				0.0	0.0	
1.13	0.0	0.005	0.0	0.005	0.984	0.0				0.001	0.01	11.7
1.40	0.0	0.007	0.0	0.007	0.993	0.0				0.001	0.05	11.7
3.97	0.0	0.062	0.0	0.062	0.981	0.0				0.001	0.18	
5.03	0.0	0.043	0.014	0.014	1.001	0.0	0.0		0.0	0.001	0.50	
6.47	0.0	0.082	0.013	0.013	0.971	0.0			0.0	0.007	0.50	10.0
7.13	0.001	0.079	0.015	0.015	0.964	0.0	4.2	0.0	18.500	0.094	1.45	
8.13	0.001	0.054	0.039	0.039	0.944	0.0		0.0	18.500	0.278	6.53	
9.13	0.001	0.007	0.055	0.060	0.803	0.010		0.001	11.500	0.450	26.55	
10.13	0.155	0.003	0.030	0.033	0.659	0.010	31.4			0.670	55.27	19.4
11.13	0.130	0.006	0.026	0.034	0.577	0.010		0.008	11.500	0.788	96.39	
12.13	0.127	0.007	0.028	0.035	0.522	0.010	13.7	0.008		0.777	143.54	
13.13	0.134	0.009	0.028	0.037	0.466	0.010		0.008	11.000	0.628	169.04	23.3
14.13	0.133	0.009	0.027	0.036					9.600	0.515	225.64	
15.13	0.116	0.007	0.028	0.035						0.306	255.11	
16.13	0.111	0.006	0.028	0.034					10.000	0.088	271.77	22.8
17.13	0.089	0.005	0.027	0.032			11.1			0.001	276.37	
18.13	0.071	0.005	0.029	0.034	0.352	0.0				0.001	276.43	
19.13	0.057	0.005	0.024	0.029	0.347	0.0				0.001	276.49	19.4
20.13	0.046	0.006	0.025	0.031	0.347	0.0				0.0	276.54	
21.13	0.038	0.009	0.025	0.034	0.347					0.001	276.55	
22.13	0.039	0.010	0.024	0.034	0.319					0.0	276.60	16.7
23.13	0.024	0.009	0.025	0.034	0.308					0.0	276.60	

a/ Interference-corrected initial [NO], [NO₂], and [NO_x] are 0.075, 0.021, and 0.096 ppm.

DAY 2, 11-10-77

25 % SUNSHINE

TIME (EST)	OZONE (PPM)	CO (PPM)	NO ₂ (PPM)	NOX (PPM)	I-SOL (PPM)	SOL ₂ (PPM)	I-P-S (UG/H3)	PM ₁₀ (PPM)	CH-5 (K-CH/CM3)	SH (L/MIN)	CU-SH (LANG) CELSIUS	TEMP CELSIUS
0.13	0.016	0.006	0.025	0.034	0.304	0.0		0.006		0.0	0.0	
1.13	0.015	0.007	0.025	0.032	0.297	0.0		0.007		0.0	0.0	16.1
2.13	0.013	0.006	0.024	0.030		0.0		0.007		0.0	0.0	
3.13	0.010	0.007	0.023	0.030	0.292	0.0		0.009		0.0	0.0	
4.13	0.007	0.006	0.023	0.029	0.280	0.0		0.010		0.0	0.0	13.9
5.13	0.006	0.008	0.023	0.027	0.274	0.0		0.010	0.340	0.0	0.0	
6.47	0.006	0.003	0.024	0.028	0.297	0.0	0.0	0.012		0.007	0.20	
7.13	0.005	0.006	0.023	0.029	0.293	0.0		0.015		0.051	0.82	15.0
8.13	0.006	0.005	0.023	0.029	0.283	0.0		0.008		0.120	4.42	
9.13	0.011	0.009	0.025	0.029	0.272	0.0		0.006	18.800	0.157	11.90	
10.13	0.017	0.008	0.027	0.033	0.275	0.0		0.012		0.145	21.23	19.4
11.13	0.023	0.008	0.036	0.039	0.290	0.0				0.247	30.73	
12.13	0.034	0.008	0.051	0.052	0.290	0.0				0.115	44.52	20.0
13.13	0.033	0.009	0.030	0.034	0.290	0.0				0.496	54.39	
14.13	0.023	0.003	0.034	0.038	0.249	0.010				0.379	63.24	
15.13	0.005	0.003	0.034	0.035	0.275	0.0				0.249	104.96	

PII STUDY, CHAMBER STUDY
USIPA CONTRACT NO. 68-02-2437

CHAMBER, 100, 2
DATA 10-11-9-77
NO₂, 0.2 ± CH₃-S-C₂H₅

71 & SUM03114

TIME (SEC)	0.250 (PPM)	100 (PPM)	1002 (PPM)	1003 (PPM)	1-SH (PPM)	502 (PPM)	1-P-5 (100/MS)	PAR (PPM)	CM-5 (K-CN/CM3)	SR (L/MIN)	CU-SM (LANG)	TEMP (CELSIUS)
0.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.0	0.0	
1.50	0.0	0.008	0.0	0.0	0.0	0.0				0.001	0.02	11.7
1.97	0.0	0.010	0.0	0.008	1.005	0.0				0.001	0.06	11.7
3.50	0.0	0.012	0.0	0.010	1.014	0.0				0.001	0.16	
5.25	0.0	0.012	0.0	0.012	0.995	0.0				0.001	0.25	
5.25	0.0	0.172	0.0	0.012	0.985	0.0				0.001	0.29	
5.40	0.0	0.169	0.001	0.210			0.0		0.0	0.007	0.56	
6.65	0.0	0.165	0.038	0.205	0.978	0.0			16.000	0.094	2.41	10.0
7.50	0.0	0.157	0.045	0.200	0.965	0.0			15.000	0.278	11.56	
8.50	0.001	0.101	0.072	0.195	0.909	0.0	15.2	0.0		0.450	40.64	
9.00	0.008	0.009	0.121	0.150	0.715	0.010	19.8	0.004	6.000	0.670	62.10	19.8
10.50	0.229	0.002	0.061	0.062	0.520	0.010			6.500	0.788	104.97	
11.50	0.227	0.005	0.057	0.060	0.400	0.010				0.777	151.51	23.5
12.50	0.232	0.006	0.053	0.059	0.554	0.010	10.5		6.500	0.626	195.48	
13.50	0.227	0.007	0.051	0.050					5.000	0.515	231.09	
14.50	0.217	0.005	0.049	0.054						0.506	258.25	
15.50	0.217	0.004	0.049	0.055					5.000	0.088	272.66	22.8
16.50	0.182	0.005	0.045	0.050			0.0			0.001	276.38	
17.50	0.150	0.004	0.045	0.049	0.258	0.010				0.001	276.84	19.8
18.50	0.150	0.005	0.044	0.049	0.266	0.0				0.001	276.50	
19.50	0.130	0.006	0.043	0.049	0.254					0.001	276.54	
20.50	0.127	0.009	0.042	0.051	0.254					0.001	276.56	16.7
22.50	0.115	0.008	0.043	0.051	0.225					0.0	276.60	
23.50	0.100	0.007	0.042	0.049						0.0	276.60	

u/ Interference-corrected Initial [NO], [NO₂], and [NO₂] are 0.163, 0.045, and 0.208 ppm.

DATA 2, 11-10-77

23 & SUM03114

TIME (SEC)	0.250 (PPM)	100 (PPM)	1002 (PPM)	1003 (PPM)	1-SH (PPM)	502 (PPM)	1-P-5 (100/MS)	PAR (PPM)	CM-5 (K-CN/CM3)	SR (L/MIN)	CU-SM (LANG)	TEMP (CELSIUS)
0.50	0.020	0.006	0.032	0.048				0.015		0.0	0.0	
1.50	0.030	0.006	0.031	0.047				0.015		0.0	0.0	16.1
2.50	0.071	0.005	0.040	0.045				0.014		0.0	0.0	
3.50	0.065	0.005	0.040	0.045				0.016		0.0	0.0	
4.50	0.075	0.004	0.040	0.048				0.019		0.0	0.0	13.9
5.50	0.040	0.002	0.037	0.059				0.015	0.0	0.0	0.0	
6.65	0.041	0.004	0.037	0.061	0.180	0.0		0.016		0.007	0.26	
7.50	0.058	0.005	0.036	0.060	0.176	0.0	0.0	0.015		0.051	1.54	15.0
8.50	0.055	0.005	0.035	0.058	0.170	0.0		0.015		0.120	5.64	
9.50	0.054	0.006	0.036	0.058	0.165	0.0		0.015	0.000	0.157	15.51	19.8
10.50	0.057	0.004	0.035	0.055	0.165	0.0		0.016		0.145	22.71	
11.50	0.054	0.005	0.034	0.054	0.159	0.0		0.015		0.247	55.25	
12.50	0.055	0.004	0.034	0.054	0.159	0.0		0.015		0.115	45.69	
13.50	0.052	0.004	0.034	0.053	0.156	0.0		0.016	1.000	0.096	59.45	20.0
14.50	0.052	0.004	0.034	0.053	0.157	0.0		0.015		0.379	67.10	
15.50	0.053	0.003	0.033	0.053				0.015	2.100	0.249	107.50	

RTI SMOG CHAMBER STUDY
USLPA CONTRACT NO. 68-02-2437

CHAMBER NO. 3
DAY 1, 11-9-77
RUN 42: CH3-S-L205 71 & SURSHIDE

TIME (EST)	02:00 (PPH)	100 (PPH)	1002 (PPH)	100 (PPH)	1-SUL (PPH)	SO2 (PPH)	1-P-S (UG/M3)	PAH (PPH)	CH-S (K-CN/CM3)	SH (L/MIN)	CU-SR (LANG) CELSIUS	TEMP CELSIUS
0.47	0.0	0.001	0.0	0.001	0.0	0.0				0.0	0.0	
1.47	0.0	0.010	0.0	0.010	1.015	0.0				0.001	0.03	11.7
2.47	0.0	0.015	0.0	0.015	1.004	0.0				0.001	0.07	
3.47	0.0	0.019	0.0	0.019	1.000	0.0				0.001	0.15	11.1
4.47	0.0	0.012	0.000	0.000	0.992	0.0				0.001	0.24	
5.47	0.0	0.000	0.001	0.001	0.988	0.0				0.001	0.30	
6.40	0.0	0.595	0.005	0.478	0.988	0.0	0.0		0.0	0.007	0.64	
7.47	0.0	0.577	0.100	0.477	0.972	0.0	0.0		23.000	0.094	3.37	10.0
8.47	0.000	0.254	0.201	0.455	0.872	0.010	5.0	0.0	17.500	0.278	14.20	
9.47	0.095	0.025	0.509	0.534	0.607	0.010		0.006		0.450	35.73	
10.47	0.541	0.003	0.153	0.156	0.536	0.010	20.5			0.670	68.93	19.4
11.47	0.355	0.005	0.152	0.157	0.218	0.010			12.500	0.777	159.43	
12.47	0.335	0.005	0.120	0.131	0.169	0.010	10.1			0.628	201.85	23.3
13.47	0.335	0.004	0.121	0.125	0.115	0.010			8.600	0.515	236.34	
14.47	0.330	0.004	0.115	0.119	0.061	0.010			7.400	0.306	261.35	
15.47	0.515	0.005	0.111	0.116	0.010	0.0	10.4		7.100	0.088	273.56	22.8
16.47	0.294	0.003	0.105	0.108						0.001	276.39	
17.47	0.268	0.004	0.103	0.107						0.001	276.45	
18.47	0.240	0.004	0.101	0.105	0.061	0.010				0.001	276.51	19.4
19.47	0.226	0.003	0.097	0.100	0.010	0.0				0.0	276.54	
20.47	0.207	0.006	0.097	0.103						0.001	276.57	
21.47	0.189	0.007	0.094	0.101						0.001	276.60	16.7
22.47	0.162	0.007	0.090	0.101						0.0	276.60	
23.47	0.158	0.004	0.093	0.097						0.0	276.60	

a/ Interference-corrected Initial [NO], [NO₂], and [NO_x] are 0.402, 0.088, and 0.490 ppm.

DAY 2, 11-10-77 23 & SURSHIDE

TIME (EST)	02:00 (PPH)	100 (PPH)	1002 (PPH)	100 (PPH)	1-SUL (PPH)	SO2 (PPH)	1-P-S (UG/M3)	PAH (PPH)	CH-S (K-CN/CM3)	SH (L/MIN)	CU-SR (LANG) CELSIUS	TEMP CELSIUS
0.47	0.146	0.005	0.091	0.096						0.0	0.0	
1.47	0.136	0.005	0.091	0.096						0.0	0.0	16.1
2.47	0.123	0.004	0.090	0.094				0.059		0.0	0.0	
3.47	0.114	0.004	0.089	0.093				0.041		0.0	0.0	
4.47	0.106	0.003	0.088	0.091				0.037		0.0	0.0	13.9
5.47	0.098	0.004	0.086	0.090				0.035	0.430	0.0	0.0	
6.40	0.088	0.002	0.085	0.087			0.0	0.059		0.007	0.34	
7.47	0.065	0.002	0.086	0.088	0.010	0.0				0.051	1.66	15.0
8.47	0.077	0.002	0.085	0.087	0.010	0.0				0.120	6.66	
9.47	0.074	0.001	0.084	0.089	0.010	0.0			0.500	0.157	15.11	
10.47	0.075	0.001	0.085	0.089	0.010	0.0				0.145	20.19	19.4
11.47	0.073	0.002	0.083	0.082	0.010	0.0				0.247	35.77	
12.47	0.091	0.002	0.080	0.082	0.010	0.0				0.115	46.86	
13.47	0.097	0.001	0.081	0.081	0.010	0.0			1.200	0.496	64.51	20.0
14.47	0.127	0.001	0.082	0.093	0.010	0.0				0.379	90.97	
15.47	0.143	0.000	0.081	0.091	0.010	0.010			2.300	0.249	110.04	

RTI 500G CHAMBER STUDY
USFPA CONTRACT NO. 68-02-2437

CHAMBER NO. 4
DAY 1, 11-9-77
RUN #2: CH3-S-C2H5

71 & 300SHMID

TIME (EST)	0204 (PPH)	NO (PPH)	NO ₂ (PPH)	NO _x (PPH)	I-50L (PPH)	502 (PPH)	I-P-S (UG/M3)	PAN (PPH)	CH-5 (K-CH/CH3)	SR (L/MIN)	CU-SR (LANG) CELSIUS	TEMP (CELSIUS)
0.63	0.0	0.001	0.0	0.001	0.0	0.0				0.0	0.0	
1.63	0.0	0.009	0.0	0.009	1.009	0.0				0.001	0.04	11.7
2.63	0.0	0.011	0.0	0.011	1.000	0.0				0.001	0.04	
3.63	0.0	0.005	0.0	0.005	0.968	0.0				0.001	0.13	
4.63	0.0	0.004	0.0	0.004	0.967	0.0				0.001	0.21	11.1
6.63	0.0	0.006	0.0	0.006	0.962	0.0	0.0		0.0	0.007	0.43	
7.63	0.0	0.007	0.0	0.007	0.952	0.0			24.000	0.094	4.27	10.0
8.63	0.0	0.008	0.0	0.008	0.924	0.0				0.276	16.67	
9.63	0.0	0.005	0.0	0.005	0.868	0.010	11.1	0.000		0.450	40.05	
10.63	0.0	0.014	0.0	0.014	0.637	0.010	26.3	0.011	15.000	0.670	75.37	19.4
11.63	0.0	0.005	0.0	0.005	0.409	0.010			19.000	0.777	120.03	
12.63	0.0	0.004	0.0	0.004	0.269	0.010			17.000	0.628	207.88	23.3
13.63	0.0	0.004	0.0	0.004	0.218	0.010	20.5		11.000	0.515	241.29	
14.63	0.0	0.004	0.0	0.004	0.207	0.010			7.100	0.306	264.29	
15.63	0.0	0.004	0.0	0.004	0.199	0.010			6.500	0.088	274.41	22.8
16.63	0.0	0.002	0.0	0.002	0.181	0.010	8.0			0.001	276.40	
17.63	0.0	0.004	0.0	0.004	0.173	0.010				0.001	276.46	
18.63	0.0	0.003	0.0	0.003	0.164	0.010				0.001	276.52	19.4
19.63	0.0	0.003	0.0	0.003	0.159	0.010				0.0	276.54	
20.63	0.0	0.005	0.0	0.005	0.154	0.010				0.001	276.58	
21.63	0.0	0.007	0.0	0.007	0.153	0.010				0.0	276.60	16.7
22.63	0.0	0.007	0.0	0.007	0.150	0.010				0.0	276.60	
23.63	0.0	0.004	0.0	0.004	0.147	0.010				0.0	276.60	

a/ Interference-corrected initial [NO], [NO₂], and [NO_x] are 0.778, 0.184, and 0.962 ppm.

DAY 2, 11-10-77

25 & 300SHMID

TIME (EST)	0204 (PPH)	NO (PPH)	NO ₂ (PPH)	NO _x (PPH)	I-50L (PPH)	502 (PPH)	I-P-S (UG/M3)	PAN (PPH)	CH-5 (K-CH/CH3)	SR (L/MIN)	CU-SR (LANG) CELSIUS	TEMP (CELSIUS)
0.63	0.273	0.005	0.142	0.147						0.0	0.0	
1.63	0.258	0.004	0.130	0.142						0.0	0.0	16.1
2.63	0.248	0.004	0.135	0.139				0.057		0.0	0.0	
3.63	0.237	0.004	0.134	0.138				0.060		0.0	0.0	
4.63	0.228	0.005	0.131	0.136				0.055		0.0	0.0	13.9
5.63	0.219	0.004	0.129	0.133				0.055	0.0	0.0	0.0	
6.63	0.207	0.002	0.124	0.126	0.0	0.0	0.0	0.057		0.007	0.41	
7.63	0.199	0.002	0.123	0.125	0.0	0.0	0.0	0.051		0.051	2.35	15.0
8.63	0.189	0.000	0.122	0.122	0.010	0.0		0.120		0.120	4.02	
9.63	0.182	0.001	0.123	0.124	0.0	0.0		0.157		0.157	16.61	
10.63	0.170	0.001	0.123	0.124	0.010	0.0		0.145	0.380	0.145	25.58	19.4
11.63	0.175	0.002	0.124	0.126	0.0	0.0		0.247		0.247	38.14	
12.63	0.175	0.001	0.125	0.127	0.0	0.0		0.115		0.115	47.97	
13.63	0.161	0.000	0.123	0.125	0.010	0.0		0.496		0.496	69.27	20.0
14.63	0.090	0.001	0.127	0.128	0.0	0.0		0.379		0.379	94.61	
15.63	0.214	0.0	0.121	0.121	0.0	0.0		0.249	1.500	0.249	112.43	

REF SHED CHAMBER STUDY
USLPA CONTRACT NO. 68-02-2437

CHAMBER No. 1
DAY 1, 11-11-77
RUN #5 : PROPHET

TIME (EST)	UZONE (PPM)	NO (PPM)	NO2 (PPM)	NOX (PPM)	PHOP (PPM)	PAH (PPM)	CH-5 (K-CH/CM3)	SR (L/MIN)	CU-SR (LANG) CELSIUS	TEMP CELSIUS
2.13	0.000	0.005	0.005	0.010	0.701			0.0	0.0	
3.13	0.001	0.003	0.005	0.008	0.690			0.0	0.0	
4.13	0.001	0.076	0.002	0.078	0.677			0.001	0.01	1.1
5.28	0.001	0.071	0.012	0.090	0.675		0.0	0.001	0.08	
7.48	0.001	0.077	0.015	0.090	0.675		0.0	0.005	0.26	
8.13	0.002	0.068	0.022	0.090	0.672	0.0		0.137	4.37	-1.1
9.13	0.025	0.029	0.059	0.088	0.653	0.000	1.500	0.374	11.56	
10.13	0.167	0.004	0.065	0.069	0.505	0.005	2.500	0.610	35.84	
11.13	0.266	0.002	0.050	0.052	0.537	0.014		0.779	73.76	
12.13	0.226	0.002	0.049	0.051	0.253	0.018		0.873	121.23	
13.13	0.185	0.004	0.049	0.053	0.199	0.019		0.873	173.61	
14.13	0.156	0.006	0.050	0.058	0.162	0.020	2.600	0.772	225.20	11.7
15.13	0.136	0.006	0.050	0.056	0.146	0.020	2.500	0.603	270.20	
16.13	0.118	0.002	0.049	0.051	0.144	0.021		0.370	304.57	
17.13	0.104	0.002	0.049	0.046	0.116	0.021	2.100	0.112	324.75	12.8
18.13	0.090	0.006	0.040	0.046	0.103	0.021		0.001	330.61	
19.13	0.083	0.002	0.037	0.039	0.096	0.021		0.0	330.66	5.6
20.13	0.075	0.004	0.037	0.041	0.093	0.021		0.0	330.66	
21.13	0.068	0.004	0.037	0.042	0.091	0.020		0.0	330.66	
22.13	0.064	0.005	0.037	0.042	0.083	0.021		0.001	330.67	0.6
23.13	0.058	0.004	0.037	0.041	0.083	0.021		0.002	330.73	

DAY 2, 11-12-77

TIME (EST)	UZONE (PPM)	NO (PPM)	NO2 (PPM)	NOX (PPM)	PHOP (PPM)	PAH (PPM)	CH-5 (K-CH/CM3)	SR (L/MIN)	CU-SR (LANG) CELSIUS	TEMP CELSIUS
0.13	0.055	0.003	0.036	0.039	0.077	0.022		0.003	0.02	
1.13	0.052	0.003	0.036	0.039	0.071	0.022		0.001	0.19	1.7
2.13	0.047	0.001	0.037	0.038	0.071	0.022		0.001	0.25	
3.13	0.046	0.002	0.036	0.040	0.067	0.022		0.001	0.31	
4.13	0.041	0.001	0.037	0.038	0.065	0.022		0.0	0.36	-1.1
5.13	0.039	0.001	0.036	0.037	0.062	0.022		0.0	0.36	
6.13	0.037	0.0	0.036	0.036	0.059	0.022		0.003	0.38	
7.13	0.035	0.0	0.037	0.037	0.061	0.023		0.201	2.11	-3.3
8.13	0.034	0.0	0.041	0.041	0.057	0.023		0.481	16.15	
9.13	0.033	0.0	0.042	0.042	0.060	0.023		0.610	46.22	
10.13	0.034	0.0	0.043	0.043	0.057	0.023		0.782	84.16	
11.13	0.037	0.001	0.044	0.045	0.051	0.023	2.500	0.871	131.77	6.7
12.13	0.040	0.002	0.045	0.047	0.051	0.023		0.873	184.05	
13.13	0.048	0.002	0.046	0.048	0.051	0.023		0.654	234.72	8.9
14.13	0.051	0.002	0.046	0.048	0.051	0.023		0.318	271.34	
15.13	0.047	0.002	0.046	0.048	0.051	0.023		0.375	290.66	
16.13	0.046	0.002	0.046	0.048	0.051	0.023		0.096	311.14	6.7
17.13	0.044	0.004	0.041	0.045	0.051	0.023		0.003	316.22	

RTI SMUG CHANNEL STUDY
USCFA CONTINACT 00, 00-02-2037

CHANNEL 00, 2
DAY 1, 11-11-77
RUN 03 : PROBEID

TIME (EST)	WZURE (PPM)	WU (PPM)	WU2 (PPM)	WU3 (PPM)	100 X SUNSHINE PHEW (PPM)	PAH (PPM)	CU-S (K-CU/CMS)	SR (L/MIN)	CU-SR (LANG)	TEMP CELSIUS
2.30	0.000	0.005	0.005	0.010	0.006			0.0	0.0	
3.30	0.001	0.003	0.004	0.007	0.006			0.0	0.0	
5.07	0.001	0.125	0.0	0.155	0.001			0.001	0.06	
6.13	0.001	0.153	0.033	0.106	0.001		0.0	0.005	0.37	-1.1
7.07	0.001	0.148	0.034	0.102	0.001	0.0	0.0	0.137	5.93	
8.30	0.002	0.133	0.019	0.102	0.001	0.0	0.300	0.374	15.37	
9.30	0.010	0.071	0.100	0.177	0.001	0.0	0.750	0.610	42.06	
10.30	0.106	0.010	0.145	0.155	0.006			0.779	61.70	8.3
11.30	0.356	0.002	0.109	0.111	0.300	0.022		0.873	130.13	
12.30	0.593	0.003	0.092	0.095	0.175	0.037		0.873	162.51	
13.30	0.346	0.005	0.091	0.096	0.148	0.039	0.690	0.772	233.08	11.7
14.30	0.309	0.008	0.092	0.100	0.081	0.039	0.950	0.603	276.35	
15.30	0.206	0.005	0.091	0.096	0.064	0.041		0.370	308.30	
16.30	0.265	0.002	0.089	0.091	0.059	0.041	0.670	0.112	325.90	12.8
17.30	0.246	0.001	0.086	0.087	0.044	0.042		0.001	330.62	
18.30	0.228	0.001	0.075	0.076	0.039	0.041		0.0	330.66	5.6
19.30	0.217	0.004	0.073	0.077	0.027	0.041		0.0	330.66	
20.30	0.210	0.004	0.073	0.077	0.027	0.041		0.0	330.66	
21.30	0.202	0.004	0.073	0.078	0.027	0.041		0.001	330.68	0.6
22.30	0.195	0.005	0.074	0.079	0.022	0.041		0.001	330.68	
23.30	0.190	0.006	0.073	0.077	0.018	0.041		0.002	330.76	

DAY 2, 11-12-77

03 X SUNSHINE

TIME (EST)	WZURE (PPM)	WU (PPM)	WU2 (PPM)	WU3 (PPM)	100 X SUNSHINE PHEW (PPM)	PAH (PPM)	CU-S (K-CU/CMS)	SR (L/MIN)	CU-SR (LANG)	TEMP CELSIUS
0.30	0.185	0.003	0.073	0.076	0.024	0.041		0.003	0.05	
1.30	0.176	0.003	0.072	0.075	0.016	0.042		0.001	0.20	1.7
2.30	0.174	0.002	0.070	0.072	0.015	0.041		0.001	0.26	
3.30	0.171	0.002	0.071	0.073	0.011	0.041		0.001	0.32	
4.30	0.166	0.001	0.071	0.072	0.011	0.042		0.0	0.36	-1.1
5.30	0.164	0.0	0.071	0.071	0.012	0.042		0.0	0.36	
6.30	0.159	0.0	0.071	0.071	0.010	0.041		0.003	0.41	-3.3
7.30	0.157	0.0	0.072	0.072	0.009	0.042		0.201	4.16	
8.30	0.155	0.0	0.077	0.077	0.010	0.042		0.481	21.26	
9.30	0.146	0.0	0.076	0.076	0.006	0.043		0.610	52.44	
10.30	0.146	0.0	0.079	0.079	0.007	0.042		0.702	92.14	6.7
11.30	0.145	0.0	0.079	0.079	0.0	0.042		0.871	140.66	
12.30	0.145	0.003	0.082	0.085	0.007	0.043	0.750	0.873	192.95	
13.30	0.147	0.002	0.082	0.084	0.007	0.043		0.654	241.39	8.9
14.30	0.144	0.002	0.082	0.084	0.007	0.043		0.518	274.58	
15.30	0.141	0.001	0.082	0.083	0.007	0.043		0.575	294.69	
16.30	0.136	0.002	0.079	0.081	0.007	0.043		0.696	312.17	6.7
17.30	0.129	0.003	0.073	0.076	0.007	0.043		0.003	316.25	

RTI SMUG CHAMBER STUDY
USEPA CONTRACT NO. 68-02-2437

CHAMBER NO. 5
DAY 1, 11-11-77
MOI 45 : PROPENE

100 % SUNSHINE

TIME (EST)	OZONE (PPH)	MO (PPH)	NO2 (PPH)	NOX (PPH)	PMOP (PPH)	PAN (PPH)	CH-5 (K-CN/CM5)	SR (L/MIN)	CU-SR (LANG)	TEMP (CELSIUS)
2.47	0.000	0.004	0.005	0.009	0.721			0.0	0.0	
3.47	0.001	0.003	0.003	0.006	0.710			0.0	0.05	1.1
4.47	0.001	0.397	0.0	0.397	0.699			0.001	0.12	
5.47	0.001	0.395	0.002	0.401	0.691		0.0	0.005	0.41	
6.47					0.607		0.0	0.137	0.58	-1.1
7.47	0.001	0.387	0.005	0.402	0.666	0.0		0.374	19.19	
8.47	0.002	0.351	0.122	0.475	0.629	0.0	0.0	0.610	48.28	
9.47	0.005	0.271	0.195	0.464	0.518	0.002	0.210	0.779	49.65	8.3
10.47	0.024	0.135	0.311	0.406	0.413	0.009		0.873	139.04	
11.47	0.109	0.037	0.371	0.408	0.270	0.023		0.673	191.42	
12.47	0.203	0.011	0.322	0.335	0.158	0.045	0.460	0.772	240.95	11.7
13.47	0.384	0.008	0.240	0.298	0.088	0.066	0.520	0.370	312.11	
14.47	0.446	0.009	0.184	0.193	0.056	0.076	0.460	0.112	327.04	12.8
15.47	0.414	0.004	0.170	0.174	0.037	0.078		0.001	330.63	
16.47	0.417	0.002	0.166	0.168	0.027	0.077		0.0	330.66	5.6
17.47	0.392	0.002	0.155	0.157	0.024	0.077		0.0	330.66	
18.47	0.372	0.001	0.145	0.146	0.016	0.074		0.0	330.66	0.6
19.47	0.357	0.004	0.142	0.146	0.014	0.074		0.001	330.69	
20.47	0.348	0.005	0.140	0.146	0.009	0.074		0.002	330.78	
21.47	0.338	0.005	0.139	0.145	0.010	0.074				
22.47	0.333	0.005	0.139	0.144	0.010	0.075				
23.47	0.326	0.004	0.135	0.139	0.010	0.075				

DAY 2, 11-12-77

83 % SUNSHINE

TIME (EST)	OZONE (PPH)	MO (PPH)	NO2 (PPH)	NOX (PPH)	PMOP (PPH)	PAN (PPH)	CH-5 (K-CN/CM5)	SR (L/MIN)	CU-SR (LANG)	TEMP (CELSIUS)
0.47	0.323	0.003	0.130	0.139	0.008	0.075		0.003	0.08	
1.47	0.317	0.003	0.136	0.139	0.005	0.075		0.001	0.21	1.7
2.47	0.315	0.002	0.136	0.138	0.0	0.075		0.001	0.27	
3.47	0.307	0.002	0.134	0.136	0.005	0.074		0.001	0.33	
4.47	0.304	0.001	0.133	0.134	0.0	0.076		0.0	0.36	-1.1
5.47	0.298	0.001	0.136	0.137	0.0	0.075		0.003	0.44	
6.47	0.296	0.0	0.136	0.138	0.0	0.075		0.201	6.21	-3.3
7.47	0.293	0.0	0.141	0.141	0.0	0.075		0.481	26.16	
8.47	0.289	0.0	0.142	0.142	0.0	0.076		0.610	58.66	
9.47	0.284	0.0	0.141	0.141	0.0	0.077		0.471	100.11	6.7
10.47	0.278	0.0	0.137	0.137	0.0	0.077		0.873	149.54	
11.47	0.277	0.0	0.144	0.144	0.0	0.077		0.873	198.19	
12.47	0.275	0.002	0.143	0.145	0.0	0.077	0.460	0.654	248.06	8.9
13.47	0.275	0.002	0.145	0.147	0.0	0.077		0.318	277.83	
14.47	0.268	0.003	0.145	0.148	0.0	0.077		0.375	298.51	
15.47	0.264	0.000	0.144	0.144	0.0	0.077		0.096	313.15	6.7
16.47	0.256	0.003	0.140	0.143	0.0	0.077		0.003	316.28	
17.47	0.247	0.004	0.134	0.138	0.0	0.077				

RTI SNUG CHAMBER STUDY
USEPA CONTRACT NO. 68-02-2437

CHAMBER NO. 4
DAY 1, 11-11-77
RUN 43 : PROPER

100 % SUNSHINE

TIME (LST)	OZONE (PPM)	NO (PPM)	NO2 (PPM)	NOX (PPM)	PROP (PPM)	PAH (PPM)	CN-5 (K-CN/CH3)	SR (L/MIN)	CU-SR (LANG) CELSIUS	TEMP CELSIUS
2.63	0.000	0.004	0.006	0.010	0.715			0.0	0.0	
3.63	0.001	0.003	0.004	0.007	0.694			0.0	0.0	1.1
4.58	0.001	0.001	0.000	0.000	0.672			0.001	0.03	
5.70	0.001	0.001	0.001	0.001	0.663		0.200	0.137	1.90	-1.1
7.18	0.001	0.001	0.001	0.001	0.674	0.000		0.374	22.78	
8.63	0.002	0.006	0.006	0.006	0.621	0.000	0.200	0.610	54.14	
9.63	0.002	0.005	0.005	0.005	0.528	0.001	0.250	0.779	97.13	0.3
10.63	0.003	0.001	0.001	0.001	0.464	0.003		0.873	147.42	
11.63	0.007	0.001	0.001	0.001	0.365	0.000		0.873	199.80	
12.63	0.018	0.001	0.001	0.001	0.303	0.012	0.620	0.772	248.36	11.7
13.63	0.032	0.001	0.001	0.001	0.242	0.018	0.950	0.603	280.29	
14.63	0.043	0.001	0.001	0.001	0.216	0.022		0.370	315.67	12.8
15.63	0.036	0.001	0.001	0.001	0.201	0.024	0.950	0.112	328.11	
16.63	0.016	0.001	0.001	0.001	0.196	0.023		0.001	330.64	
17.63	0.000	0.001	0.001	0.001	0.197	0.023		0.001	330.66	5.6
18.63	0.000	0.001	0.001	0.001	0.193	0.022		0.0	330.66	
19.63	0.000	0.001	0.001	0.001	0.195	0.022		0.0	330.66	
20.63	0.000	0.001	0.001	0.001	0.194	0.023		0.0	330.66	
21.63	0.000	0.001	0.001	0.001	0.195	0.022		0.001	330.70	0.6
22.63	0.000	0.001	0.001	0.001	0.195	0.022		0.001	330.70	
23.63	0.000	0.001	0.001	0.001	0.198	0.022		0.002	330.79	

DAY 2, 11-12-77

63 % SUNSHINE

TIME (LST)	OZONE (PPM)	NO (PPM)	NO2 (PPM)	NOX (PPM)	PROP (PPM)	PAH (PPM)	CN-5 (K-CN/CH3)	SR (L/MIN)	CU-SR (LANG) CELSIUS	TEMP CELSIUS
0.63	0.000	0.036	0.552	0.588	0.171	0.023		0.003	0.11	
1.63	0.000	0.035	0.546	0.583	0.187	0.023		0.001	0.22	1.7
2.63	0.000	0.035	0.536	0.571	0.184	0.023		0.001	0.24	
3.63	0.000	0.035	0.527	0.562	0.181	0.023		0.001	0.34	
4.63	0.000	0.035	0.520	0.555	0.180	0.023		0.0	0.36	-1.1
5.63	0.000	0.034	0.516	0.550	0.168	0.022		0.0	0.36	
6.63	0.000	0.034	0.512	0.546	0.171	0.023		0.003	0.47	
7.63	0.020	0.034	0.506	0.536	0.169	0.023		0.201	4.14	-3.3
8.63	0.039	0.034	0.491	0.519	0.154	0.027		0.001	30.78	
9.63	0.055	0.034	0.487	0.492	0.142	0.031		0.010	64.52	
10.63	0.078	0.034	0.481	0.482	0.115	0.038		0.010	107.62	6.7
11.63	0.114	0.032	0.476	0.476	0.094	0.045	0.620	0.010	157.90	
12.63	0.148	0.021	0.466	0.466				0.073	210.24	
13.63	0.169	0.011	0.459	0.459				0.054	250.34	6.9
14.63	0.155	0.006	0.453	0.453				0.318	280.84	
15.63	0.154	0.005	0.453	0.453				0.375	302.11	
16.63	0.133	0.005	0.453	0.453				0.096	314.67	6.7
17.63	0.109	0.004	0.453	0.453				0.003	316.31	

R11 SHUG. CHAMBER STUDY
USEPA CONTRACT NO. 68-02-2437

CHAMBER NO. 1
DAY 1, 11-13-77
RUN 00 : PMIDE

TIME (EST)	OZONE (PPM)	HI (PPM)	HI2 (PPM)	HI3 (PPM)	100 % SUNSHINE PROP (PPM)	PAN (PPM)	CR-5 (K-CN/CM3)	SR (L/MIN)	CU-SR (LANG)	TEMP (CELSIUS)
2.13	0.0	0.0	0.001	0.001	0.627			0.0	0.0	
5.02	0.001	0.007	0.001	0.001				0.001	0.00	
6.30	0.000	0.003	0.020	0.102	0.601		0.0	0.004	0.13	-3.9
7.13	0.0	0.082	0.021	0.103	0.596	0.0	0.0	0.209	1.93	
8.13	0.000	0.073	0.023	0.098	0.585	0.0	0.320	0.508	16.00	
9.13	0.015	0.039	0.060	0.099	0.529	0.002	0.410	0.606	16.05	
10.13	0.108	0.009	0.076	0.085	0.494	0.010	0.410	0.774	15.72	3.9
11.13	0.242	0.003	0.055	0.058	0.251	0.018	1.400	0.862	132.84	
12.13	0.247	0.0	0.047	0.047	0.212	0.021		0.862	189.56	
13.13	0.198	0.001	0.047	0.049		0.021		0.768	235.55	5.8
14.13	0.166	0.001	0.049	0.050		0.021		0.597	280.30	
15.13	0.139	0.002	0.050	0.051		0.021	0.950	0.363	314.29	
16.13	0.119	0.001	0.049	0.050		0.021	0.520	0.186	316.07	6.7
17.13	0.105	0.0	0.045	0.045		0.023		0.001	339.61	
18.13	0.094	0.002	0.040	0.042		0.020		0.0	339.66	1.7
19.13	0.085	0.005	0.036	0.041		0.019		0.0	339.66	
20.13	0.078	0.006	0.035	0.041		0.020		0.001	339.67	
21.13	0.071	0.006	0.034	0.040		0.019		0.001	339.73	0.0
22.13	0.066	0.006	0.035	0.041		0.020		0.001	339.79	
23.13	0.064	0.006	0.035	0.042				0.001		

DAY 2, 11-14-77

TIME (EST)	OZONE (PPM)	HI (PPM)	HI2 (PPM)	HI3 (PPM)	100 % SUNSHINE PROP (PPM)	PAN (PPM)	CR-5 (K-CN/CM3)	SR (L/MIN)	CU-SR (LANG)	TEMP (CELSIUS)
0.13	0.058	0.006	0.034	0.040		0.020		0.001	0.01	
1.13	0.056	0.005	0.036	0.041		0.019		0.001	0.07	-1.7
2.13	0.052	0.004	0.037	0.041		0.019		0.002	0.14	
3.13	0.048	0.005	0.036	0.040				0.003	0.26	-3.9
4.13	0.046	0.004	0.038	0.042				0.002	0.44	
5.13	0.044	0.003	0.039	0.041				0.0	0.54	
6.13	0.042	0.003	0.040	0.043				0.003	0.56	-6.1
7.13	0.038	0.001	0.042	0.045			0.200	0.202	2.30	
8.13	0.036	0.001	0.045	0.044				0.265	14.91	
9.13	0.033	0.004	0.043	0.047		0.021		0.530	32.67	3.9
10.13	0.032	0.004	0.043	0.046		0.021		0.589	64.42	
11.13	0.033	0.003	0.045	0.048		0.020	0.0	0.621	99.44	
12.13	0.030	0.003	0.045	0.047		0.020		0.633	149.24	
13.13	0.044	0.002	0.046	0.048		0.021		0.739	198.48	8.3
14.13	0.047	0.001	0.046	0.045		0.022		0.571	241.51	
15.13	0.051	0.001	0.046	0.048		0.022	0.0	0.348	274.03	
16.13	0.051	0.002	0.046	0.048		0.022		0.091	292.91	10.0

RTI SHOG CHAMBER STUDY
USEPA CONTRACT NO. 68-02-2437

CHAMBER NO. 2
DAY 1, 11-15-77
RUN #4 : PROPEN

100 % SUNSHINE

TIME (EST)	OZONE (PPM)	HO (PPM)	HO2 (PPM)	HOX (PPM)	PROP (PPM)	PAN (PPM)	CH-5 (K-CLN/CM3)	SH (L/MIN)	CU-SR (LANG) CELSIUS	TEMP (L/MIN)
2.30	0.0	0.0	0.002	0.002	0.641			0.0	0.0	
4.30	0.001	0.101	0.0	0.101	0.625			0.0	0.0	-2.2
5.30	0.009	0.158	0.042	0.200	0.568			0.001	0.06	
6.30	0.0	0.157	0.042	0.200	0.614		0.0	0.004	0.21	
7.30	0.0	0.145	0.052	0.197	0.592		0.0	0.204	8.06	-5.9
8.30	0.009	0.094	0.070	0.190	0.575	0.0	0.200	0.508	21.98	
9.30	0.073	0.027	0.151	0.178	0.490	0.002	0.250	0.774	93.61	3.9
10.30	0.230	0.008	0.134	0.142	0.352	0.011	0.460	0.862	141.64	
11.30	0.360	0.003	0.097	0.100	0.231	0.029		0.768	193.16	
12.30	0.353	0.001	0.089	0.091	0.152	0.040		0.597	203.38	5.6
13.30	0.309	0.002	0.089	0.091		0.042		0.363	266.39	
14.30	0.278	0.002	0.088	0.089		0.043	0.250	0.106	335.15	6.7
15.30	0.252	0.001	0.088	0.089		0.041	0.250	0.001	339.62	
16.30	0.234	0.000	0.084	0.084		0.039		0.0	339.66	1.7
17.30	0.219	0.002	0.074	0.077		0.039		0.0	339.66	
18.30	0.208	0.004	0.072	0.076		0.039		0.001	339.68	
19.30	0.199	0.006	0.071	0.071		0.038		0.001	339.74	0.0
20.30	0.192	0.006	0.071	0.077		0.038		0.001	339.74	
21.30	0.186	0.006	0.069	0.075		0.038		0.001	339.74	
22.30	0.180	0.005	0.070	0.076		0.038		0.001	339.80	
23.30										

DAY 2, 11-14-77

89 % SUNSHINE

TIME (EST)	OZONE (PPM)	HO (PPM)	HO2 (PPM)	HOX (PPM)	PROP (PPM)	PAN (PPM)	CH-5 (K-CLN/CM3)	SH (L/MIN)	CU-SR (LANG) CELSIUS	TEMP (L/MIN)
0.30	0.176	0.006	0.070	0.075		0.038		0.001	0.02	
1.30	0.169	0.005	0.070	0.075		0.038		0.001	0.04	-1.7
2.30	0.167	0.006	0.070	0.075		0.039		0.002	0.16	
3.30	0.163	0.005	0.072	0.077				0.003	0.29	
4.30	0.159	0.004	0.074	0.078				0.002	0.46	-5.9
5.30	0.157	0.003	0.070	0.079				0.0	0.54	
6.30	0.152	0.002	0.070	0.078				0.003	0.59	-6.1
7.30	0.150	0.001	0.071	0.078			0.200	0.202	4.36	
8.30	0.147	0.001	0.070	0.079		0.038		0.265	17.01	
9.30	0.141	0.004	0.070	0.083		0.039		0.550	38.28	3.9
10.30	0.137	0.002	0.070	0.082		0.038		0.549	70.82	
11.30	0.134	0.003	0.071	0.083		0.040		0.821	108.26	
12.30	0.135	0.002	0.071	0.083		0.039		0.833	157.73	8.5
13.30	0.137	0.002	0.072	0.084		0.039	0.200	0.739	206.02	
14.30	0.138	0.001	0.071	0.082		0.040		0.571	247.30	
15.30	0.139	0.001	0.072	0.083		0.040		0.348	277.58	10.0
16.30	0.136	0.002	0.070	0.082		0.039	0.0	0.091	293.84	
17.30								0.0	297.66	

RTI SMOG CHAMBER STUDY
USEPA CONTRACT NO. 68-02-2437

CHAMBER NO. 5
DAY 1, 11-13-77
RUN 44 1 PHIPPHNE

100 % SUNSHINE

TIME (EST)	OZONE (PPH)	NO (PPH)	NO2 (PPH)	NOX (PPH)	PHOP (PPH)	PAN (PPH)	CH-5 (K-CH/CM3)	SR (L/MIN)	CU-SR (LANG)	TEMP CELSIUS
2.47	0.000	0.0	0.002	0.002	0.667			0.0	0.0	
3.15	0.001	0.0	0.001	0.001	0.637			0.0	0.0	
4.62	0.001	0.0	0.001	0.001	0.618			0.0	0.0	-2.2
5.13	0.000	0.0	0.001	0.001	0.602			0.001	0.04	
6.00	0.0	0.0	0.001	0.001	0.592		0.0	0.004	0.25	
7.47	0.0	0.0	0.001	0.001	0.592		0.0	0.204	0.19	-3.9
8.47	0.000	0.0	0.001	0.001	0.580	0.000	0.210	0.508	27.17	
9.47	0.003	0.002	0.001	0.001	0.509	0.001	0.210	0.606	60.41	
10.47	0.012	0.003	0.001	0.001	0.435	0.005	0.320	0.774	101.51	3.9
11.47	0.040	0.003	0.001	0.001	0.354	0.013		0.862	150.43	
12.47	0.139	0.009	0.001	0.001	0.238	0.027		0.862	202.15	
13.47	0.259	0.009	0.001	0.001	0.044	0.054		0.768	251.22	5.6
14.47	0.299	0.006	0.001	0.001	0.054	0.061	0.280	0.597	292.48	
15.47	0.318	0.003	0.001	0.001	0.054	0.058	0.250	0.363	321.70	
16.47	0.297	0.001	0.001	0.001	0.057	0.057		0.106	336.23	6.7
17.47	0.271	0.000	0.001	0.001	0.056	0.057		0.001	339.63	
18.47	0.251	0.004	0.001	0.001	0.056	0.056		0.0	339.66	1.7
19.47	0.238	0.005	0.001	0.001	0.057	0.057		0.0	339.66	
20.47	0.228	0.006	0.001	0.001	0.057	0.057		0.001	339.69	
21.47	0.219	0.007	0.001	0.001	0.057	0.057		0.001	339.75	0.0
22.47	0.213	0.006	0.001	0.001	0.056	0.056		0.001	339.81	
23.47	0.207	0.005	0.001	0.001						

DAY 2, 11-14-77

89 % SUNSHINE

TIME (EST)	OZONE (PPH)	NO (PPH)	NO2 (PPH)	NOX (PPH)	PHOP (PPH)	PAN (PPH)	CH-5 (K-CH/CM3)	SR (L/MIN)	CU-SR (LANG)	TEMP CELSIUS
0.47	0.202	0.006	0.108	0.115	0.057			0.001	0.03	
1.47	0.198	0.005	0.111	0.116	0.057			0.001	0.09	-1.7
2.47	0.192	0.006	0.112	0.117	0.057			0.002	0.18	
3.47	0.189	0.005	0.113	0.118				0.003	0.32	-3.9
4.47	0.186	0.003	0.115	0.118				0.002	0.48	
5.47	0.181	0.003	0.115	0.118				0.0	0.54	
6.47	0.179	0.003	0.115	0.118				0.003	0.62	-6.1
7.47	0.177	0.003	0.115	0.118	0.057	0.058	0.0	0.202	6.42	
8.47	0.171	0.003	0.117	0.120	0.058	0.058		0.265	20.31	
9.47	0.167	0.003	0.115	0.118	0.058	0.058		0.530	43.69	3.9
10.47	0.164	0.003	0.115	0.118	0.058	0.058		0.549	76.02	
11.47	0.162	0.002	0.119	0.121	0.058	0.058		0.821	116.63	
12.47	0.167	0.002	0.122	0.124	0.059	0.059		0.833	166.23	
13.47	0.173	0.002	0.122	0.125	0.059	0.059	0.0	0.719	213.56	8.3
14.47	0.178	0.001	0.121	0.123	0.060	0.060		0.571	253.16	
15.47	0.179	0.002	0.122	0.124	0.060	0.060		0.348	281.13	
16.47	0.175	0.002	0.121	0.124	0.058	0.058	0.0	0.091	294.77	10.0
17.47		0.002	0.121	0.124				0.0	297.66	

RTI SNUG, CHAMBER STUDY
USLPA CLINICAL NO. 68-02-2037

CHAMBER NO. 4
DAY 10, 11-13-77
MIDN. 04:00 PROPHEL

100% SUNSHINE

TIME (EST)	U2004 (PPM)	U01 (PPM)	U02 (PPM)	U03 (PPM)	PROP (PPM)	PAN (PPM)	CU-S (K-CU/CM3)	SH (L/MIN)	CU-SR (LANG)	TEMP (CELSIUS)
2.03	0.000	0.0	0.005	0.003	0.629			0.0	0.0	
3.30	0.001	0.0	0.0	0.0	0.621			0.0	0.0	-2.2
4.30	0.001	0.0	0.0	0.0	0.616			0.001	0.02	
5.00	0.001	0.0	0.005	0.001	0.610			0.004	0.29	
6.07	0.0	0.0	0.029	0.070	0.610		0.0	0.209	0.20	-3.9
7.03	0.0	0.0	0.020	0.071	0.614		0.0	0.508	32.04	
8.03	0.0	0.0	0.020	0.071	0.575		0.0	0.606	36.23	
9.03	0.000	0.0	0.039	0.093	0.586		0.0	0.774	108.94	3.9
10.03	0.001	0.0	0.032	0.095	0.533		0.210	0.862	158.70	
11.03	0.005	0.0	0.072	0.095	0.433		0.240	0.862	210.82	
12.03	0.009	0.0	0.113	0.091	0.393			0.760	258.59	5.6
13.03	0.016	0.0	0.232	0.099	0.340			0.597	298.21	
14.03	0.016	0.0	0.185	0.097	0.792			0.363	325.18	
15.03	0.013	0.0	0.159	0.096	0.765			0.106	337.25	6.7
16.03	0.004	0.0	0.139	0.096	0.745		0.210	0.001	339.64	
17.03	0.0	0.0	0.132	0.094	0.726		0.200	0.0	339.66	
18.03	0.0	0.0	0.131	0.093	0.713			0.0	339.66	1.7
19.03	0.0	0.0	0.110	0.077	0.707			0.0	339.66	
20.03	0.0	0.0	0.110	0.064	0.693			0.001	339.70	
21.03	0.0	0.0	0.110	0.062	0.692			0.001	339.76	0.0
22.03	0.0	0.0	0.128	0.057	0.685			0.001	339.82	
23.03	0.0	0.0	0.127	0.053	0.680			0.001	339.82	

DAY 2, 11-18-77

80% SUNSHINE

TIME (EST)	U2004 (PPM)	U01 (PPM)	U02 (PPM)	U03 (PPM)	PROP (PPM)	PAN (PPM)	CU-S (K-CU/CM3)	SH (L/MIN)	CU-SR (LANG)	TEMP (CELSIUS)
0.03	0.0	0.129	0.550	0.678		0.016		0.001	0.04	
1.03	0.0	0.123	0.540	0.670		0.017		0.001	0.10	-1.7
2.03	0.009	0.121	0.542	0.663		0.017		0.002	0.20	
3.03	0.000	0.121	0.539	0.660				0.003	0.35	
4.03	0.000	0.119	0.539	0.658				0.002	0.50	-3.9
5.03	0.001	0.116	0.535	0.651				0.0	0.58	
6.03	0.001	0.113	0.533	0.647				0.003	0.65	
7.03	0.008	0.123	0.539	0.642			0.340	0.202	8.36	-6.1
8.03	0.016	0.123	0.533	0.636				0.265	22.86	
9.03	0.031	0.115	0.480	0.575		0.018		0.510	88.77	
10.03	0.036	0.089	0.403	0.572		0.020		0.584	81.29	3.9
11.03	0.069	0.067	0.473	0.540		0.023		0.613	128.51	
12.03	0.099	0.041	0.452	0.493		0.016		0.719	178.23	8.3
13.03	0.125	0.027	0.423	0.450		0.044	0.650	0.719	220.65	
14.03	0.138	0.016	0.388	0.403		0.044		0.571	258.68	
15.03	0.129	0.007	0.388	0.358		0.039		0.348	288.97	
16.03	0.104	0.005	0.343	0.308		0.051		0.001	295.68	10.0
17.03				0.308		0.051	0.250	0.0	297.68	

RTI SMOG CHAMBER STUDY
US EPA CONTRACT NO. 68-02-2837

CHAMBER NO. 3
DAY 1, 11-10-77
RUN #6 11-10-77
a/ 100 X SUNSHINE

TIME (EST)	OZONE (PPM)	NO (PPM)	NO2 (PPM)	NOX (PPM)	1-SUL (PPM)	SU2 (PPM)	PAN (PPM)	CN-5 (K-CN/CM3)	SR (L/MIN)	CU-SR (LANG) CELSIUS	TEMP CELSIUS
0.13	0.0	0.0	0.001	0.001	0.574	0.0	0.0	0.380	0.0	0.0	6.7
1.13	0.0	0.001	0.001	0.002	0.562	0.0	0.0	0.580	0.0	0.0	6.1
2.13	0.0	0.252	0.0	0.252	0.553	0.0	0.0	44.000	0.001	0.01	6.1
3.13	0.0	0.247	0.051 b/	0.298 b/	0.538	0.0	0.0	60.000	0.001	0.06	6.1
4.13	0.0	0.241	0.052	0.292	0.530	0.0	0.0	60.000	0.001	0.07	6.1
5.13	0.0	0.237	0.053	0.288	0.530	0.0	0.0	60.000	0.001	0.08	6.1
6.13	0.0	0.235	0.053	0.286	0.530	0.0	0.0	60.000	0.001	0.09	6.1
7.13	0.001	0.209	0.068	0.277	0.530	0.0	0.0	60.000	0.001	0.10	6.1
8.13	0.002	0.128	0.128	0.252	0.530	0.0	0.0	60.000	0.001	0.11	6.1
9.13	0.008	0.087	0.184	0.120	0.530	0.0	0.0	60.000	0.001	0.12	6.1
10.13	0.008	0.087	0.184	0.120	0.530	0.0	0.0	60.000	0.001	0.13	6.1
11.13	0.008	0.087	0.184	0.120	0.530	0.0	0.0	60.000	0.001	0.14	6.1
12.13	0.008	0.087	0.184	0.120	0.530	0.0	0.0	60.000	0.001	0.15	6.1
13.13	0.008	0.087	0.184	0.120	0.530	0.0	0.0	60.000	0.001	0.16	6.1
14.13	0.008	0.087	0.184	0.120	0.530	0.0	0.0	60.000	0.001	0.17	6.1
15.13	0.008	0.087	0.184	0.120	0.530	0.0	0.0	60.000	0.001	0.18	6.1
16.13	0.008	0.087	0.184	0.120	0.530	0.0	0.0	60.000	0.001	0.19	6.1
17.13	0.008	0.087	0.184	0.120	0.530	0.0	0.0	60.000	0.001	0.20	6.1
18.13	0.008	0.087	0.184	0.120	0.530	0.0	0.0	60.000	0.001	0.21	6.1
19.13	0.008	0.087	0.184	0.120	0.530	0.0	0.0	60.000	0.001	0.22	6.1
20.13	0.008	0.087	0.184	0.120	0.530	0.0	0.0	60.000	0.001	0.23	6.1
21.13	0.008	0.087	0.184	0.120	0.530	0.0	0.0	60.000	0.001	0.24	6.1
22.13	0.008	0.087	0.184	0.120	0.530	0.0	0.0	60.000	0.001	0.25	6.1
23.13	0.008	0.087	0.184	0.120	0.530	0.0	0.0	60.000	0.001	0.26	6.1

a/ 2-Methylthiophene

b/ Interference-corrected initial [NO], [NO2], and [PAN] are 0.238, 0.060, and 0.208 ppm.

DAY 2, 11-19-77

99 X SUNSHINE

TIME (EST)	OZONE (PPM)	NO (PPM)	NO2 (PPM)	NOX (PPM)	1-SUL (PPM)	SU2 (PPM)	PAN (PPM)	CN-5 (K-CN/CM3)	SR (L/MIN)	CU-SR (LANG) CELSIUS	TEMP CELSIUS
0.13	0.022	0.006	0.045	0.051	0.010	0.0	0.024	0.030	0.0	0.0	1.1
1.13	0.019	0.006	0.044	0.050	0.010	0.0	0.024	0.030	0.001	0.01	1.1
2.13	0.017	0.005	0.045	0.050	0.010	0.0	0.024	0.030	0.001	0.07	1.1
3.13	0.015	0.005	0.044	0.049	0.010	0.0	0.024	0.030	0.0	0.12	1.1
4.13	0.014	0.003	0.044	0.047	0.010	0.0	0.024	0.030	0.0	0.12	1.1
5.13	0.013	0.004	0.043	0.047	0.010	0.0	0.024	0.030	0.001	0.13	2.2
6.13	0.012	0.003	0.043	0.046	0.010	0.0	0.024	0.030	0.162	1.44	2.2
7.13	0.010	0.004	0.042	0.046	0.010	0.0	0.024	0.030	0.398	13.00	10.0
8.13	0.010	0.004	0.042	0.046	0.010	0.0	0.024	0.030	0.504	38.02	10.0
9.13	0.016	0.004	0.042	0.046	0.010	0.0	0.024	0.030	0.704	71.91	10.0
10.13	0.020	0.004	0.042	0.046	0.010	0.0	0.024	0.030	0.788	114.61	10.0
11.13	0.026	0.002	0.036	0.039	0.010	0.0	0.024	0.030	0.788	162.06	14.4
12.13	0.036	0.002	0.036	0.039	0.010	0.0	0.024	0.030	0.788	208.56	14.4
13.13	0.050	0.001	0.035	0.036	0.010	0.0	0.024	0.030	0.788	249.64	14.4
14.13	0.061	0.001	0.034	0.035	0.010	0.0	0.024	0.030	0.802	279.56	15.0
15.13	0.065	0.001	0.033	0.034	0.010	0.0	0.024	0.030	0.802	295.47	15.0
16.13	0.061	0.001	0.032	0.033	0.010	0.0	0.024	0.030	0.802	295.47	15.0

CHAMBER NO. 2
DAY 1, 11-10-77
RUN 46:1 THIOPHENES^{a/} 100 X SUNSHINE

RTI SMUG CHAMBER STUDY
USEPA CONTRACT NO. 68-02-2437

TIME (EST)	OZONE (PPH)	NO (PPH)	NO2 (PPH)	NOX (PPH)	I-SUL (PPH)	SU2 (PPH)	PAH (PPH)	CN-5 (K-CN/CM3)	SR (L/MIN)	CU-SR (LANG)	TEMP CELSIUS
0.30	0.0	0.000	0.002	0.002	0.503	0.0			0.0	0.0	
1.30	0.0	0.0	0.0	0.0	0.466	0.0			0.0	0.0	6.7
3.25	0.0	0.295	0.0	0.295	0.481	0.0			0.001	0.0	6.1
4.30	0.0	0.291 b/	0.033 b/	0.324 b/	0.455	0.0			0.001	0.06	
5.55	0.0	0.287	0.030	0.317	0.360	0.010		0.0	0.001	0.08	
6.30	0.0	0.284	0.029	0.313	0.272	0.0		0.0	0.093	1.74	6.1
7.30	0.001	0.276	0.033	0.309	0.205	0.106	0.000	17.000	0.531	11.66	
8.30	0.004	0.238	0.062	0.300	0.176	0.0	0.0	29.000	0.569	35.40	
10.30	0.017	0.128	0.134	0.262	0.153	0.010			0.755	72.69	12.2
11.30	0.074	0.039	0.132	0.171	0.132	0.010	0.008	30.000	0.824	118.51	
12.30	0.133	0.012	0.085	0.097	0.205	0.106	0.018		0.824	167.95	
13.30	0.163	0.003	0.062	0.065	0.176	0.113	0.027	34.000	0.734	215.77	15.0
14.30	0.157	0.0	0.059	0.059	0.153	0.101	0.030	33.000	0.567	256.81	
15.30	0.146	0.002	0.037	0.059	0.132	0.085	0.030	29.000	0.356	266.67	14.4
16.30	0.135	0.002	0.026	0.058	0.114	0.010	0.028		0.0	305.70	
17.30	0.117	0.001	0.054	0.055	0.010	0.010	0.028		0.0	305.70	8.9
18.30	0.104	0.001	0.053	0.054	0.010	0.010	0.028		0.0	305.70	
19.30	0.098	0.001	0.052	0.053	0.010	0.010	0.026		0.0	305.70	
20.30	0.086	0.007	0.051	0.050	0.010	0.0	0.027		0.001	305.72	2.2
21.30	0.079	0.008	0.050	0.050					0.001	305.78	
22.30	0.076	0.007	0.051	0.050					0.001		
23.30	0.071	0.007	0.051	0.050					0.001		

a/ 2-Methylthiophene

b/ Interference-corrected initial [NO], [NO₂], and [NO_x] are 0.242, 0.066 and 0.308 ppm.

DAY 2, 11-19-77

99 X SUNSHINE

TIME (EST)	OZONE (PPH)	NO (PPH)	NO2 (PPH)	NOX (PPH)	I-SUL (PPH)	SU2 (PPH)	PAH (PPH)	CN-5 (K-CN/CM3)	SR (L/MIN)	CU-SR (LANG)	TEMP CELSIUS
0.30	0.066	0.005	0.048	0.053	0.010	0.0	0.027		0.0	0.0	
1.30	0.064	0.004	0.049	0.053	0.010	0.0	0.027		0.001	0.02	1.1
2.30	0.059	0.004	0.048	0.052	0.010	0.0	0.026		0.001	0.08	
3.30	0.056	0.004	0.048	0.052	0.010	0.0	0.025		0.0	0.12	
4.30	0.053	0.003	0.047	0.050	0.010	0.0	0.024		0.0	0.12	1.1
5.30	0.051	0.003	0.047	0.050	0.010	0.0	0.022		0.0	0.12	
6.30	0.049	0.002	0.046	0.048	0.010	0.0	0.021		0.001	0.14	
7.30	0.046	0.003	0.045	0.048	0.010	0.0	0.019	0.0	0.162	3.10	2.2
8.30	0.044	0.003	0.046	0.049	0.010	0.0	0.021		0.398	17.06	
9.30	0.043	0.003	0.045	0.048	0.010	0.0	0.024	0.320	0.544	43.57	
10.30	0.046	0.003	0.044	0.047	0.010	0.010	0.024	0.320	0.704	79.09	10.0
11.30	0.063	0.002	0.044	0.046	0.010	0.010	0.024	0.540	0.788	122.84	
12.30	0.083	0.001	0.045	0.046	0.010	0.010	0.024		0.788	170.07	
13.30	0.105	0.001	0.043	0.044	0.010	0.010	0.022		0.708	215.74	14.4
14.30	0.120	0.001	0.042	0.043	0.010	0.010	0.022		0.528	255.02	
15.30	0.126	0.001	0.041	0.042	0.010	0.010	0.020	1.000	0.302	282.64	
16.30	0.120	0.001	0.039	0.040	0.010	0.010	0.020	0.950	0.070	296.58	15.0

RTI SMUG CHAMBER STUDY
USEPA CONTRACT NO. 68-02-2437

CHAMBER NO. 3
DAY 1, 11-18-77
RUN 46: THIOPHENES^{a/} 100 % SUNSHINE

TIME (EST)	OZONE (PPM)	NO (PPM)	NO2 (PPM)	NOX (PPM)	I-SUL (PPM)	SO2 (PPM)	PAH (PPH)	CN-5 (K-CN/CH3)	SR (L/MIN)	CU-SH (LANG)	TEMP (CELSIUS)
0.47	0.0	0.0	0.001	0.001					0.0	0.0	
1.47	0.0	0.0	0.001	0.001					0.0	0.0	6.7
3.70	0.0	0.261	0.0	0.261	0.381	0.0			0.001	0.03	6.1
4.47	0.0	0.257 b/	0.047 b/	0.304 b/	0.370	0.0		0.0	0.001	0.09	
5.10	0.0	0.250	0.045	0.295	0.364	0.0		0.590	0.001	0.09	6.1
6.47	0.0	0.245	0.050	0.295	0.357	0.0		22.000	0.001	0.09	
7.47	0.001	0.238	0.056	0.294	0.360	0.0		29.000	0.001	0.09	6.1
9.47	0.004	0.199	0.055	0.204	0.330	0.0	0.000		0.331	15.03	
10.47	0.010	0.128	0.131	0.259	0.283	0.010	0.003		0.569	41.61	
11.47	0.029	0.066	0.155	0.221	0.223	0.010	0.008	36.000	0.733	60.37	12.2
12.47	0.056	0.032	0.151	0.163	0.155	0.010	0.016		0.824	126.92	
13.47	0.089	0.017	0.132	0.149	0.126	0.010	0.022	32.000	0.824	176.36	
14.47	0.104	0.007	0.114	0.121	0.090	0.010	0.028	33.000	0.734	223.26	15.0
15.47	0.107	0.005	0.102	0.107	0.066	0.010	0.033		0.567	262.59	
16.47	0.094	0.004	0.092	0.096	0.010	0.010	0.033	31.000	0.536	290.09	
17.47	0.076	0.003	0.085	0.088	0.010	0.010	0.034		0.082	303.09	14.4
18.47	0.068	0.003	0.080	0.083	0.010	0.010	0.033		0.0	305.70	
19.47	0.054	0.003	0.076	0.079	0.010	0.010			0.0	305.70	8.4
20.47	0.047	0.008	0.073	0.081	0.0	0.0	0.032		0.0	305.70	
21.47	0.044	0.008	0.071	0.079			0.033		0.0	305.70	
22.47	0.038	0.010	0.068	0.078			0.031		0.001	305.73	2.2
23.47	0.035	0.008	0.068	0.076			0.032		0.001	305.79	

a/ 2, 5-Dimethylthiophene
b/ Interference corrected initial [NO], [NO₂], and [NO_x] are 0.246, 0.064, and 0.310 ppm.

DAY 2, 11-19-77
99 % SUNSHINE

TIME (EST)	OZONE (PPM)	NO (PPM)	NO2 (PPM)	NOX (PPM)	I-SUL (PPM)	SO2 (PPM)	PAH (PPH)	CN-5 (K-CN/CH3)	SR (L/MIN)	CU-SH (LANG)	TEMP (CELSIUS)
0.47	0.032	0.006	0.066	0.072			0.032		0.0	0.0	
1.47	0.029	0.006	0.065	0.071			0.031		0.001	0.03	1.1
2.47	0.027	0.006	0.064	0.070			0.030		0.001	0.09	
3.47	0.024	0.004	0.064	0.068			0.030		0.0	0.12	
4.47	0.023	0.003	0.062	0.065			0.028		0.0	0.12	1.1
5.47	0.021	0.004	0.063	0.067			0.025		0.0	0.12	
6.47	0.019	0.002	0.062	0.064			0.024		0.001	0.15	
7.47	0.018	0.003	0.061	0.064			0.019	0.990	0.162	0.75	2.2
8.47	0.019	0.003	0.061	0.064	0.010	0.0	0.025		0.398	21.12	
9.47	0.031	0.003	0.058	0.061	0.010	0.0	0.030	1.700	0.544	49.12	
10.47	0.040	0.001	0.056	0.057	0.010	0.0	0.029	2.400	0.704	66.27	10.0
11.47	0.052	0.001	0.059	0.060	0.010	0.010	0.028	2.500	0.704	130.08	
12.47	0.076	0.001	0.058	0.059	0.010	0.010	0.033		0.704	178.08	
13.47	0.103	0.002	0.057	0.057	0.010	0.010	0.030		0.704	223.01	18.4
14.47	0.122	0.001	0.055	0.056	0.010	0.010	0.028		0.528	260.41	
15.47	0.126	0.001	0.053	0.054	0.010	0.010	0.028	2.500	0.302	285.72	
16.47	0.120	0.001	0.052	0.053	0.010	0.0	0.027	2.000	0.070	297.29	15.0

RTI 3M0G CHAMBER STUDY
USEPA CONTRACT NO. 68-02-2437

CHAMBER NO. 9
DAY 1, 11-10-77
RUN 46: THIOPHENE S^a/ 100 X SUNSHINE

TIME (EST)	UZONE (PPM)	NO (PPM)	NO2 (PPM)	NOX (PPM)	I-SUL (PPM)	SU2 (PPM)	PM (PPM)	CN-5 (R-CN/CM3)	SR (L/MIN)	(U-SR (L/MIN))	TEMP (C/SUS)
0.63	0.0	0.000	0.001	0.001					0.0	0.0	
1.63	0.0	0.0	0.0	0.0					0.0	0.0	6.7
4.60	0.0	0.249 b/	0.055 b/	0.304 b/	0.764	0.0			0.001	0.05	6.1
6.63	0.0	0.239	0.061	0.300	0.746	0.0			0.001	0.10	
7.63	0.0	0.236	0.064	0.300	0.743	0.0		0.540	0.093	3.64	6.1
8.63	0.001	0.229	0.064	0.293	0.741	0.0	0.0	17.000	0.331	18.21	
9.63	0.003	0.292	0.084	0.266	0.729	0.0	0.0	16.500	0.569	47.07	
10.63	0.006	0.152	0.113	0.265	0.671	0.010	0.000		0.733	67.41	12.2
11.63	0.014	0.100	0.141	0.241	0.614	0.010	0.001		0.824	134.63	
12.63	0.026	0.065	0.147	0.212	0.556	0.010	0.001	32.000	0.624	184.27	
13.63	0.035	0.095	0.141	0.186	0.503	0.010	0.003		0.734	230.31	15.0
14.63	0.037	0.034	0.131	0.165	0.457	0.010			0.567	268.03	
15.63	0.032	0.024	0.127	0.153	0.421	0.010	0.003	27.000	0.336	293.32	14.4
16.63	0.015	0.016	0.120	0.144	0.403	0.010			0.042	303.68	
17.63	0.001	0.007	0.134	0.141	0.369	0.010			0.0	305.70	
18.63	0.0	0.007	0.133	0.140	0.358	0.0			0.0	305.70	8.9
19.63	0.0	0.008	0.132	0.140	0.340	0.0	0.003		0.0	305.70	
20.63	0.0	0.012	0.129	0.141	0.335				0.0	305.70	
21.63	0.0	0.014	0.125	0.139	0.329		0.003		0.001	305.74	2.2
22.63	0.0	0.015	0.124	0.139	0.322				0.001	305.80	
23.63	0.0	0.015	0.123	0.138	0.322				0.001	305.80	

^a/ Thiophene
b/ Interference-corrected initial [NO], [NO₂], and [NO_x] are 0.248, 0.060, and 0.308 ppm.

DAY 2, 11-10-77

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TIME (EST)	UZONE (PPM)	NO (PPM)	NO2 (PPM)	NOX (PPM)	I-SUL (PPM)	SU2 (PPM)	PM (PPM)	CN-5 (R-CN/CM3)	SR (L/MIN)	(U-SR (L/MIN))	TEMP (C/SUS)
0.63	0.0	0.014	0.120	0.134	0.320		0.003		0.0	0.0	1.1
1.63	0.0	0.014	0.117	0.131	0.315		0.003		0.001	0.04	
2.63	0.0	0.013	0.115	0.128	0.312		0.003		0.001	0.10	
3.63	0.0	0.014	0.113	0.127	0.308		0.003		0.0	0.12	1.1
4.63	0.0	0.014	0.111	0.125	0.306		0.003		0.0	0.12	
5.63	0.0	0.014	0.111	0.125	0.299		0.003		0.001	0.16	
6.63	0.0	0.015	0.107	0.122	0.296		0.002	12.400	0.162	6.30	2.2
7.63	0.000	0.025	0.093	0.110	0.294		0.002		0.394	24.94	
8.63	0.017	0.033	0.075	0.100	0.286	0.0	0.002		0.544	54.34	
9.63	0.026	0.031	0.063	0.095	0.263	0.010	0.003	29.000	0.704	93.03	10.0
10.63	0.030	0.020	0.057	0.062	0.221	0.010	0.003	4.800	0.788	138.45	
11.63	0.060	0.011	0.051	0.047	0.216	0.010	0.004		0.785	185.61	
12.63	0.062	0.007	0.040	0.035	0.186	0.010	0.004		0.708	229.60	14.4
13.63	0.095	0.004	0.033	0.025	0.164	0.010	0.005		0.524	265.44	
14.63	0.097	0.002	0.023	0.025	0.147	0.010	0.005	23.000	0.302	288.62	
15.63	0.087	0.001	0.021	0.022	0.132	0.010	0.005	11.500	0.070	297.97	15.0
16.63	0.073	0.001	0.021	0.022	0.132	0.010					